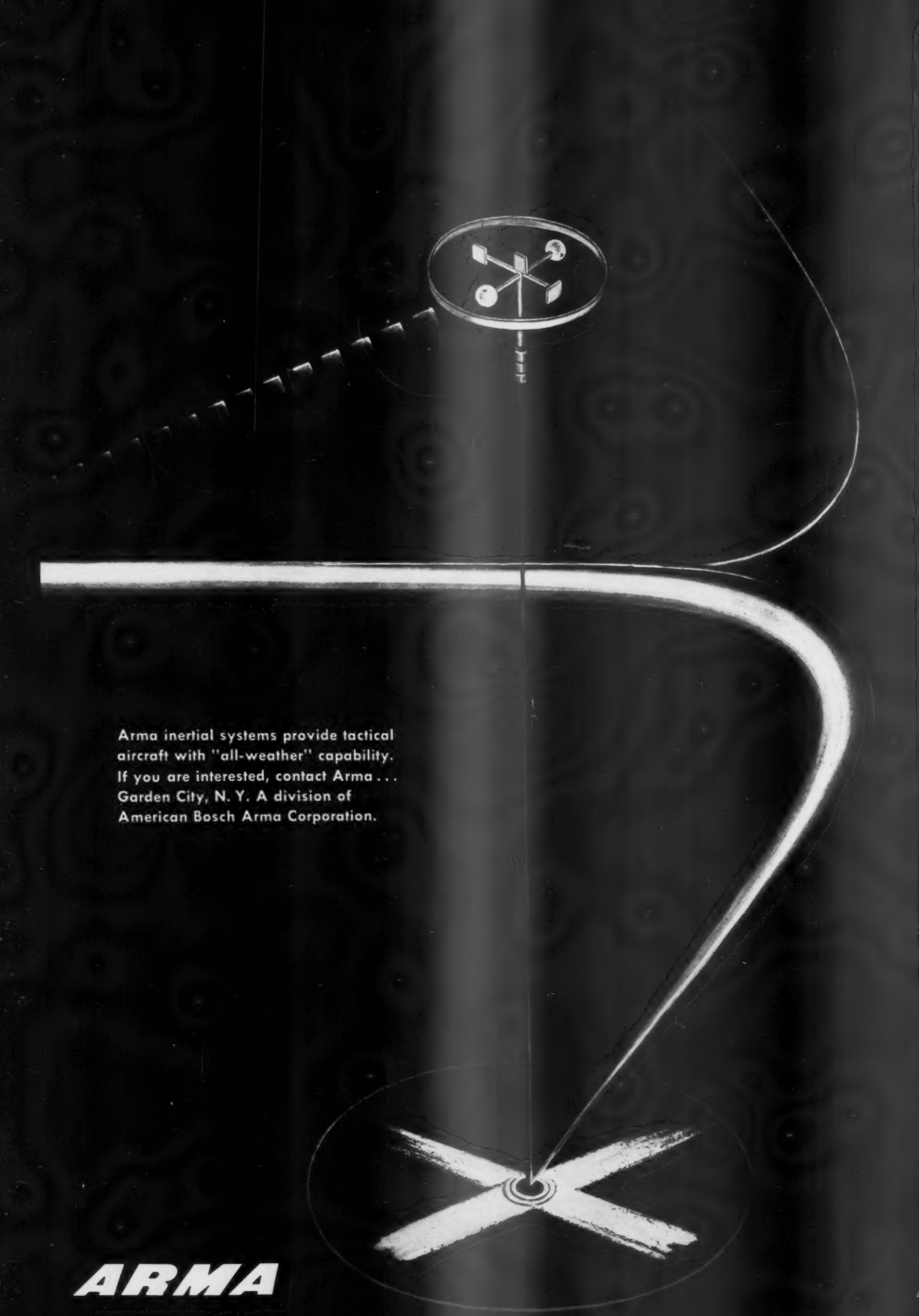
DEPARTMENT OF TECHNOLOGY
COUNTY PUBLIC LIBRARY

Aeronautical Engineering REVIEW

December, 1956


Arma inertial systems provide tactical aircraft with "all-weather" capability. If you are interested, contact Arma . . . Garden City, N. Y. A division of American Bosch Arma Corporation.
ARMA

Aeronautical Engineering Review

Vol. 15—No. 12 December, 1956

CONTENTS

Recent Developments in Braking of High-Speed Test Vehicles..... *Claude A. Brosterhous and Hugh B. Thompson* 26

Experimental Hyperballistics..... *H. H. Kurzweg and R. E. Wilson* 32

Passenger Air-Line Economics..... *Lloyd B. Aschenbeck* 39

The Problems of the Turbojet Engine as a Propulsion Engine for Supersonic Flight..... *M. J. Zucrow* 44

Vertical Scanning Air-Borne Radar for Reducing Hazards of Aircraft Icing and Ground Collisions..... *Louis J. Battan* 52

A Graphical Method for Determining the Aerodynamic and Economic Characteristics of Turboprop Air-Line Transport Systems..... *Ralph W. Allen* 55

Index to Volume 15..... 183

IAS News Notes..... 17

IAS News..... 19

Editorial..... 24

Aeronautical Reviews..... 101

International Aeronautical Abstracts..... 109

Books..... 163

Personnel Opportunities..... 177

IAS Preprints..... 189

Index to Advertisers..... 191

New Products and Product Literature..... 193

Cover—The Beechcraft model 95, a four-place twin-engine executive airplane with a cruising speed of about 200 m.p.h., has been announced by Beech Aircraft Corporation. Powered by two 180-hp. Lycoming engines and built under wraps at Beechcraft's main Wichita plant, the new airplane is undergoing tests to assure deliveries as early as possible in 1957. Beech says that for the customer seeking a small twin, the model 95 enlarges the field of selection to three units in the $35,000–55,000 price range.

Published Monthly by the

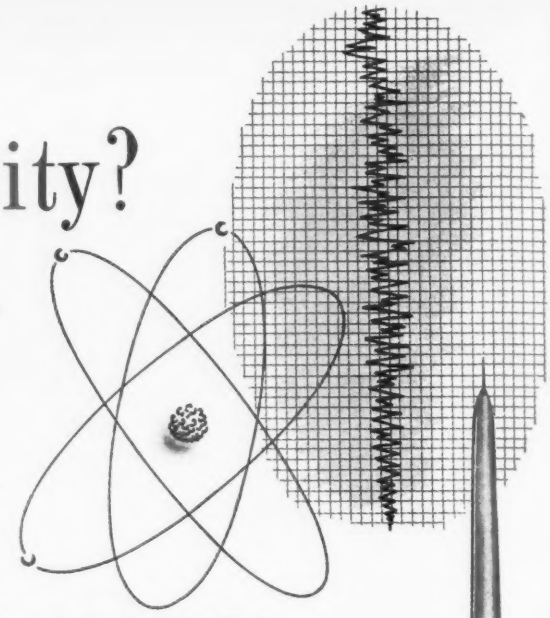
Institute of the Aeronautical Sciences, Inc.

2 East 64th Street, New York 21, N.Y.

Western Office: 7600 Beverly Blvd., Los Angeles 36, Calif.

FIRST OF A SERIES

What is reliability?



Industry in the United States is becoming more and more complex... we're getting automated ... computers are computing... the missiles are flying... the digits are digitizing...

And the word "Reliability" takes a new and different meaning... what does it mean to you?

It's time to stop and take a look! Ask three of your friends how they define "reliability." You'll be surprised at the different answers you receive. And when you quiz them further on how much reliability is needed in a particular product... how they would control the design and manufacture of that product to obtain the amount of reliability they want... you'll be even more surprised by the variety of the answers.

So... let's define reliability. Let's start off with a definition that is gaining the most acceptance in the technical field...

The reliability of a particular component or system of components is the probability that it will do what it is supposed to do under operating conditions for a specified operating time.

Looks simple enough!

But what hazards it presents! The first important challenge is that word "probability"... it takes you seriously into the field of data collection and statistical analysis. Then you check into the phrase "do what it is supposed to do"... someone must define these objectives. And, look at the "operating conditions"... pause briefly and reflect on the many different conditions under which products operate. And, finally, note the phrase "for a specified operating time"... does one normally, consciously, define reliability in terms of time?

These considerations pose problems for all of us... the manufacturers of components, those who assemble components into other products, systems personnel, designers, industrial engineers, production workers, purchasing agents, quality control... *and users!*

Let's look at the word "probability."

Picture a chain, with its successive links. Many of today's systems, simple or complex, comprise such a chain of components. However, as we all know, that chain will be only as reliable as its weakest link. And, statistically, the over-all reliability of the chain or system is the mathematical product of the reliabilities of the individual links expressed as...

Over-all Reliability, $R_0 = r_1 \times r_2 \times r_3 \ldots r_n$

As an example, assume a product has a chain of 100 components in which each component has a reliability of 99 per cent... which assumes that only one out of a hundred units of each component will fail. These are relatively high standards established by past practices. But what happens? Multiplying .99 by itself one hundred times ($.99^{100}$), note that our chain of components will have a reliability of only 36.5 per cent! Two out of three of our chains would probably fail!

As another example, let's look at contacts in a multi-contact electric connector. If, for instance, we are to assemble connectors containing 25 similar contacts from a 1% defective contact population, we can expect 22% of the connector assemblies to contain one or more defective contacts! See how the multiplication of probabilities presents a major challenge to both designer and manufacturer?

But all is not lost! There is another side of the picture. With proper care, analysis, and control, our organization at Cannon has actually achieved, in special "missile quality" contacts, a known level of only $2.85 \times 10^{-3}\%$ defective... or one defective part in 35,000! Naturally, we don't achieve

that with all our contacts . . . but we do try to design and manufacture the utmost in reliability required for specific applications.

However, to return to your problems and to go a step further in demonstrating "probability" of uncontrolled contacts . . . and the challenges it poses to you and to us . . . consider the case where we have three groups of contacts, each group with contacts of different sizes. Let us assume, also, that each group has different percentage defective populations and that the three groups are assembled in a 90-contact connector as follows:

50 No. 16 contacts with a population reliability of .59;
25 No. 12 contacts, reliability .60; and 15 No. 8 contacts, reliability .64.

Then . . .

$$R_c \text{ (90 contact connector)} = r_{\#16} \times r_{\#12} \times r_{\#8}$$

or,

$$R_c \text{ (90 contact connector)} = (.59)\ (.60)\ (.64) = .23$$

It is apparent from the above that connector contact populations must be maintained at extremely low values of percentage defective. This is of extremely vital importance if we are to produce connector assemblies which will perform satisfactorily in systems utilizing series circuitry, where the failure of one contact pair can cause failure of the entire system.

We have been talking only about *a contact* . . . just one of the many different materials and parts (such as contact pins, insulators, shells, and couplings) going into the more than 20,000 different connector and electrical items we manufacture. Think of the "product of reliabilities" rule in systems comprised of tens, hundreds, or thousands of electrical components connected by connectors such as ours. Regardless of whether they design, manufacture, sell, or use washing machines or guided missiles, everyone faces the same problem. That's why we're taking some of your valuable time to present the important subject of reliability here.

*

All of us, when we specify materials, parts or components must constantly keep in mind the (a) "probabilities," (b) what the part is supposed to do, (c) the operating conditions, and (d) the time it must operate satisfactorily. Let's see what we can do to increase reliability in relation to these four factors:

(a) Probabilities. To increase the reliability of any component, and thereby the system as a whole, it is necessary to think in terms of statistical distribution of important physical properties. From field reports of failure and laboratory test results, we must first isolate those properties which most frequently cause trouble. It is then necessary to determine whether poor performance is due to lack of process control to keep the product within specified tolerance limits, whether the dollar sign has entered into the picture too far—cutting reliability down for the sake of a few cents here or there—or whether the design itself is inadequate for an end-use application. In any case, the use of the statistical approach to problem solution offers a positive method of obtaining known levels of reliability.

(b) Definition of Function of Product. Each component and each system . . . both civilian and military . . . in each different field of endeavor, in each product produced, has different functions. None of us should "overbuild" . . . nor should we "under-build." We should look at our specifications closely.

(c) Operating Conditions. Temperature and pressure, humidity, corrosive atmospheres, stray electric and magnetic fields, low and high frequency noise, shock and vibration . . . all must be considered plus conditions prior to product use.

(d) Operating Time. This varies both for different products and different fields of application. Have you set reasonable lengths of operating time for your product or system, from the viewpoints of both usage and economics?

*

We at Cannon Electric are proud of our historical emphasis on quality and reliability. Since our inception in 1915 we have consistently adhered to a design philosophy embracing the highest quality and reliability in each Cannon Plug for the specific application for which it is to be used. *If we cannot design to that principle, we don't make it!* In manufacture, we are proud of our know-how in depth, proud of our fine quality control systems, proud of our personnel, and proud of our reliability control group. The "Cannon Credo" . . . part and parcel of the everyday life of each Cannon employee . . . is posted in all offices and all departments of all eight Cannon plants around the world. Three of its sections read as follows:

To develop an organization of exceptional people possessed of respect for the dignity of the individual and imbued with the spirit of the team.

To provide a facility with which we can produce to our utmost in an efficient and pleasant environment.

To develop and produce products of such quality, and render such service, that we may always be proud of our efforts.

*

Whenever *you* have an electric connector reliability problem . . . in design, engineering, production or prototype phases . . . we would welcome the opportunity of discussing it with you.

Cordially,

Robert J. Cannon *President*

CANNON ELECTRIC COMPANY
3208 Humboldt St., Los Angeles 31, California

Please Refer to Dept. 105

CANNON PLUGS

Eight plants around the seven seas!

MORE THAN MUSCLE

The airplane changes radically, and product requirements with it, but man remains much the same. Today it requires more than muscle to bridge this ever-widening gap between "Century-Series" aircraft and unchanging man.

At G. M. Giannini & Co., Inc. over 30 different types of engineers are combining technological skill with scientific knowledge to help bridge this gap.

Let this experience work for you by calling in your Giannini field engineer. You will gain from his ability and from the Company's decade of experience in solving instrumentation problems for major airframe manufacturers.

When accurate, reliable instruments and controls are *demanded*, specify Giannini precision-crafted products . . . products which are created with more than muscle.

Giannini-equipped North American F-100C undergoing visual check prior to take-off.

Giannini
INSTRUMENTS · CONTROLS

Engineering positions are open at several Giannini locations for career-minded young men—write for details.

G. M. GIANNINI & COMPANY, INC. • 918 EAST GREEN STREET • PASADENA, CALIF.

c

IF.

T
y
b
P
fi
pa
fi
h
o
fl
m
E
(
A
C

A
F
n
S
d
H
t
b

I.A.S. News Notes

December 1956

IN MEMORIAL

LESTER DURAND GARDNER
Founder - IAS
August 7, 1876 - November 23, 1956
(Please turn to Pages 24 & 25)

THE COUNCIL HAS VOTED unanimous acceptance of the offer of an annonymous donor to establish an IAS Water-Based Aviation Award. Its purpose, briefly, will be to stimulate water-based aircraft research and development. Plans are being formulated as rapidly as possible to add the new award to the five to be presented at the Institute's 25th Annual Meeting. (See following page.) Though the many details incidental to establishing an award are not in final form, current plans call for presentation of a certificate and a $300 honorarium. The award will honor the memory of Edwin C. Musick, pioneer of overseas air transport routes, killed while piloting the first commercial flight from the U. S. to New Zealand on January 12, 1938. The Awards Committee is composed of Captain Walter S. Diehl, USN (Ret.) (HF), Consulting Engineer; Hugh L. Dryden, (HF, HM), Director, NACA; Jerome C. Hunsaker, (HF), Professor of Aeronautical Engineering, MIT; Grover Loening, (F, B), Aircraft Consultant; and Rear Admiral James S. Russell, USN, (F, HM), Chief of the Bureau of Aeronautics.

CANDIDATES for the Institute of the Aeronautical Sciences Flight Test Engineering Fellowship are reminded that the deadline for applications is March 1, 1957. Qualifications consist of a Bachelor's degree in engineering (received before June 1957) and United States citizenship. Application forms may be obtained by a request in writing, endorsed by a sponsoring reference, to Flight Test, Institute of the Aeronautical Sciences, 2 East 64th Street, New York 21, N. Y. Total value of the award is $4,700.

AFTER 15 YEARS AS CHAIRMAN OF NACA, Jerome C. Hunsaker, (HF), Professor of Aeronautical Engineering at Massachusetts Institute of Technology, a Founder, and first President of the Institute of the Aeronautical Sciences in 1933, has been succeeded by James H. Doolittle, (HF), Vice President and a Director of Shell Oil Company - President of the IAS in 1940. Dr. Hunsaker will continue to serve as a NACA Member. Doolittle, who was retired from the Air Corps in 1946 with the rank of Lieutenant General, has been a Member of the Committee since 1948.

THE 1956 ELMER A. SPERRY AWARD, given for "a distinguished engineering contribution which, through application proved in actual service, has advanced the art of transportation, whether by land, sea, or air", was presented on October 5 to Donald W. Douglas, (HF, B), for his DC series of commercial airliners.

I.A.S. News Notes (con't.)

NATIONAL MEETINGS CALENDAR

Dec. 17 Wright Brothers Lecture, U. S. Chamber of Commerce Building Auditorium, Washington, D. C., 3 p.m. "Comments on Some Aviation Topics" by Sir Arnold Hall.

Jan. 28 thru 31 Twenty-Fifth Annual Meeting, Sheraton-Astor Hotel, New York.

Mar. 14 and 15 Flight Propulsion Meeting (Classified) Hotel Carter, Cleveland.

June 17 thru 20 National Summer Meeting, Biltmore Hotel, Los Angeles, Calif.

Sept. 1 thru 16 Sixth International Aeronautical Conference, Royal Aeronautical Society and the IAS, Folkestone, England.

SECTION MEETINGS CALENDAR

Dec. 4 Boston Section: Specialist Meeting, Wayland Laboratory, Raytheon Manufacturing Company, 8 p.m. "Automobile Stability and Control as Seen by the Aeronautical Engineer" by David W. Whitcomb.

Dec. 5 Hampton Roads Section: Specialist Meeting, Parkview School, Warwick, Va., 8 p.m. "Organization of the Office of the Special Assistant to the President for Aviation Facilities Planning" by J. Gordon Bennett, Jr.

Dec. 5 Philadelphia Section: Dinner Meeting, Penn Sherwood Hotel, 6:30 p.m. "Universal Landing Gear, Catapults and Arresting Gear in STOL Operation" by Robert B. Cotton, Howard Green, and Charles J. Daniels.

Dec. 5 Wichita Section: Dinner Meeting, Shirkmere Hotel, 7 p.m. (Social Hour at 6:30 p.m. sponsored by Air Supply, Inc.) "Human Defectiveness in Weapons System Performance" by Lt. Col. James H. Ritter, USAF.

Dec. 6 New York Section: Dinner Meeting, Main Plant New Cafeteria, Grumman Aircraft Engineering Corporation, Bethpage, L.I., 7:30 p.m. (Social Hour, 7:00 p.m. sponsored by Grumman.) "The Airlines Look at Turbines" by Franklin W. Kolk.

Dec. 6 San Diego Section: Specialist Meeting, IAS Building, 8 p.m. "Recent Flight Test Activities at Edwards AFFTC" by Colonel Horace A. Hanes, USAF.

Dec. 7 Rocky Mountain Section: Dinner Meeting, Alps Lodge, (2 miles west of Boulder Canyon) 6:30 p.m. "Scope of the IGY Program" by Walter O. Roberts.

Dec. 11 Los Angeles Section: Specialist Meeting, IAS Building, 8 p.m. "Estimation of Reliability Growth in a Complex System with Poison-Type Failure" by Herbert K. Weiss.

Dec. 20 Los Angeles Section: Dinner Meeting, IAS Building, 7 p.m. (Social Hour, 6 p.m.) "The DC-8 Jet Transport - Introduction into Airline Service" by I. L. Shogran.

IAS News

A Record of People and Events of Interest to Institute Members

25 Sessions, Panel Discussions Set for Institute's 25th Annual Meeting

Missiles, Air Space Utilization, Aeroelasticity Among Topics; Edward P. Curtis, Eisenhower Aide for Aviation Facilities Planning, Will Be Honors Night Dinner Speaker

TWENTY-FIVE SESSIONS and panel discussions—one for each year the IAS has been in existence—have been slated for the Institute's Twenty-Fifth Annual Meeting at the Sheraton-Astor Hotel, New York, January 28–31. The program looms as one of the most comprehensive ever held. All three Services will be represented in a Missiles Session that promises to vie for interest with sessions on Air Space, Aeroelasticity, and Satellites. Its Chairman will be Clark B. Millikan, HFIAS, Chairman, Aircraft and Guided Missiles Panel, USAF, Scientific Advisory Board.

The total number of sessions represents a record for any IAS meeting, with papers in excess of the 82 given at the last Annual Meeting being presented.

In several fields of interest, more than one session has been arranged. In order to avoid night sessions—while still presenting as much information as possible—there will be one morning during which four simultaneous sessions will take place.

Honors Night Dinner speaker will be Edward P. Curtis, Special Assistant to President Eisenhower for Aviation Facilities Planning. Mr. Curtis was appointed on March 1, being granted a leave of absence as Vice-President, Eastman Kodak Company, Rochester, N.Y. A veteran of both world wars, he holds nine military decorations.

Speakers at three luncheons scheduled will be Rear Adm. Luis de Florez, USN (Ret.) (FIAS), Consulting Engineer, The de Florez Co.; Rear Adm. Rawson Bennett II, USN, an IAS Honorary Member, Chief of Naval Research; and Courtland D. Perkins, AFIAS, Chief Scientist, U.S. Air Force, formerly of Princeton University.

Multiple sessions are scheduled in Aerodynamics, Aeroelasticity, Helicopter, and Materials. Two of three Aerodynamics sessions will be chairmanned by Theodore von Kármán, HFIAS, AGARD Chairman for NATO, and by W. F. Sears, FIAS, Director, Graduate School of Aeronautical Engineering, Cornell University, and Editor of the JOURNAL OF THE AERONAUTICAL SCIENCES.

Martin Goland, AFIAS, Vice-President, Southwest Research Institute, will head one of two Aeroelasticity sessions—Robert Rosenbaum, AFIAS, Chief, Dynamics and Loads Group, CAA, the other.

Brigadier Gen. Marvin C. Demler, USAF, AFIAS, Deputy Commander, Research and Development, ARDC, will chairman two Materials sessions. J. L. Anast, Systems Planning Adviser to Mr. Curtis, will chairman the session on Air Space Utilization for Air Traffic and National Defense.

The Earth Satellites Session will be headed by Joseph Kaplan, AFIAS, Professor of Physics, University of California, and Chairman, National Committee for the IGY. The Electronics Session will be headed by David S. Little, MIAS, Superintendent, Airway Aids and Electronics, American Airlines, Inc. Hugh L. Dryden, HFIAS, Director, NACA, will lead the Flight Propulsion Session. The Rocket Propulsion Session will be chairmanned by Brig. Gen. John B. Medaris, Commander, Army Ballistic Missile Agency, Redstone Arsenal.

Chairman of the Flight Safety and Flight Testing sessions will be, respectively, Jerome Lederer, FIAS, Director, Cornell-Guggenheim Aviation Safety Center, and Flight Safety Foundation, and Ray Tenhoff, President, The Society of Experimental Test Pilots. Chairman of two Helicopter sessions have not yet been chosen.

Edward P. Curtis

Robert F. Fletcher, Chief of Scientific Services, Directorate, Air Weather Services, will head the session on Meteorology, and Brig. Gen. Leighton I. Davis, USAF, Commander, Holloman Air Development Center, will lead the Self-Contained Navigation Systems Session.

The Stability and Control Session will be headed by Walter O. Breuhaus, MIAS, Head, Flight Research Department, Cornell Aeronautical Laboratory, Inc., and the Structures Session will be headed by Nicholas J. Hoff, FIAS, Head, Department of Aeronautical Engineering and Applied Mechanics, Polytechnic Institute of Brooklyn.

Alexander Satin, Senior Scientific Adviser, Development Planning Department, Lockheed Aircraft Corporation, will be chairman of the VTOL-STOL Session.

Chairmen have been chosen for two of three panel discussions. They are Medical Aspects of Aircraft Accident Investigation, Dr. John R. Poppen, AFIAS, Consultant in Aviation Medicine, Douglas Aircraft Company, Inc.; and Education, John W. Hoover, MIAS, Associate Professor of Aeronautical Engineering, University of Florida. The third discussion will be on Management.

Seven sessions will be in cooperation with other groups. They are Helicopter I and II, American Helicopter Society,

Inc.; Meteorology, American Meteorological Society; Education, American Society for Engineering Education, Aeronautical Division; Flight Safety, Daniel and Florence Guggenheim Aviation Safety Center at Cornell University; Flight Testing, Society of Experimental Test Pilots; Self-Contained Navigation Systems, Institute of Radio Engineers and Radio Technical Commission for Aeronautics.

Edward R. Sharp, retiring IAS President, will be Toastmaster at the Honors Night Dinner and will present the John Jeffries, Robert M. Losey, Sylvanus Albert Reed, and Lawrence Sperry awards. He will announce the election of Honorary Fellows and Fellows, both American and foreign for 1956, and will introduce those present.

The IAS Annual Business Meeting (all members invited) will be at 5 p.m. Wednesday, January 30. Reports on the year's activities and finances will be delivered. IAS Council vacancies will be filled by election. A Nominating Committee will be appointed for the coming year.

The business career of Mr. Curtis, the Honors Night speaker, has been with Eastman Kodak exclusively. He joined the company in 1920, and his election to a vice-presidency followed cessation of World War II hostilities. At that time, he was placed in charge of motion-picture film business throughout the world and was made responsible for general business in Europe. In January, 1954, he also took over jurisdiction of the Rochester Export Sales Department—sales to Latin America and the Far East.

R. Paul Harrington Is Named Director of AGARD Training Center in Belgium

The Training Center for Experimental Aerodynamics, established in mid-summer by NATO's Advisory Group for Aeronautical Research and Development with support of the Belgian government, will be directed by R. Paul Harrington, an Associate Fellow of the Institute. His appointment was made on the recommendation of Theodore von Kármán, AGARD Chairman and an IAS Honorary Fellow, at whose instigation the Center was formed.

Dr. Harrington has been given 2 years' leave of absence from his duties as Head of the Department of Aeronautical Engineering at Rensselaer Polytechnic Institute to become the Center's first director. At R.P.I., Joseph V. Foa, also an Associate Fellow of the IAS, has been named Acting Head of the Department of Aeronautical Engineering.

Dr. Harrington arrived in Europe late in September. His first month there was scheduled to be taken up with duties as consultant to C. C. Furnas, United States Assistant Secretary of Defense (Research and Development), who is an IAS Fellow. The opening of the Training Center, in newly equipped buildings at Rhodes Ste. Genèse, Belgium, had been slated for October.

It was expected that Dr. Harrington and his faculty of four advanced specialists in aerodynamics would have a student body of 25 or more during the first year of work, each student holding a diploma in engineering, the equivalent of a Master's degree in the United States. Those showing exceptional ability will be asked to stay another year for continued study.

Dr. Harrington's career includes teaching and aerodynamic research at R.P.I., the Polytechnic Institute of Brooklyn, the University of Michigan, and the Guggenheim Airship Institute.

R. Paul Harrington

In consideration of the appointment, Dr. von Kármán wrote Livingston W. Houston, President of R.P.I.: "It was decided that the Center needs as Technical Director an American expert of high standing and most renowned reputation. After careful screening of the qualified persons who may be interested in the position and after consultation with the U.S. Air Force, we found the best qualified person would be Professor Harrington."

Dr. Harrington expressed keen appreciation of the honor paid him. The directorship of the Center offers many opportunities to expand his research in aerodynamics, he pointed out. He will have also the tremendous advantage of being in easy flying distance from the centers of aerodynamic research in England, Germany, France, and the other NATO nations. This will open the way for personal conference with the top men of science in this field.

Dr. Harrington said he expected that the number of students will increase steadily and that the Center's work will win enthusiastic support in the NATO countries.

Two Corporate Members of IAS Among Founders of New Firm

Socony Mobil Oil Company, Inc., and United States Rubber Company, both Corporate Members of the Institute, are among ten of America's large corporations that have formed a new company, Industrial Reactor Laboratories, Inc.

The new firm will build and operate a privately owned nuclear reactor for industrial research in atomic energy at Plainsboro, N.J. Its organization was announced on September 26.

New Scholarship Fund Is Announced at M.I.T.

Jerome Clarke Hunsaker, HFIAS, Professor of Aeronautical Engineering at Massachusetts Institute of Technology, has announced six new prize scholarships of $2,200 each for the year 1956–1957 for freshmen entering M.I.T. The scholarships have been established by Mrs. John Jay Ide, of New York, to honor the memory of her father, the late William H. Donner.

The scholarships are for students planning to study in M.I.T.'s course in aeronautical engineering, the oldest program of its kind in the country. Awards are for students of high character who have given promise of future achievement in aeronautics.

Mr. Donner, for whom the scholarships are named, died in 1953 in Canada. He had been noted for his many philanthropies in the education and medical fields.

He was successively Manager of Donner Milling Company; Manager and Treasurer of National Tinplate Company, Anderson, Ind.; President of Union Steel Company and of Cambria Steel Company, both in Pittsburgh; Chairman of the Board of Pennsylvania Steel Company; and President of Donner Steel Company, Buffalo. He also was the founder of the towns of Monessen and Donora in Pennsylvania.

Mrs. Ide, by whom the scholarships have been established, is the wife of John Jay Ide who, for many years, was the European Representative of the NACA at the American Embassy at Paris, France. Her gift was inspired by the shortage of qualified scientists in the United States, particularly in the field of aeronautical engineering.

Richard Whitcomb Wins NACA'S Top Award for Discovery, Verification of Area Rule

A Member of the Institute has received the highest award of the National Advisory Committee for Aeronautics. He is Richard T. Whitcomb, of Hampton, Va., Aeronautical Research Scientist of the NACA's Langley Aeronautical Laboratory at Langley Field, Va.

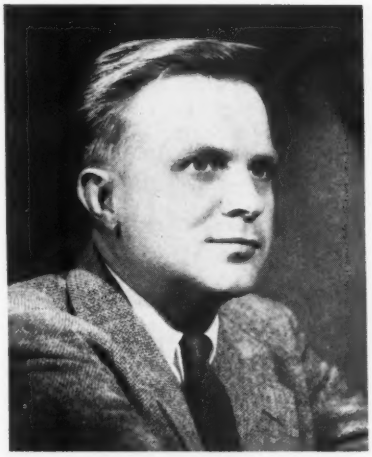
The Distinguished Service Medal was conferred upon Mr. Whitcomb on September 28 at a regular meeting of the Committee by Jerome C. Hunsaker, HFIAS, NACA Chairman, in Washington, D.C. The IAS Member is the first person to receive the award since it was established last year. He also may be the youngest ever to receive it; he is 35.

The citation accompanying the Medal said that Mr. Whitcomb, "by his discovery and experimental verification of the Area Rule, accomplished in the period 1951–1952 through the skillful use of the new NACA transonic wind tunnels, provided a novel and useful means of increasing, by as much as 25 per cent, and without additional power, the speed of airplanes in supersonic flight. Initial application of the NACA Area Rule made possible supersonic flight by military airplanes which hitherto were limited to subsonic speed. At a time when it is imperative that the United States maintain air supremacy, Mr. Whitcomb's contribution is of immeasurable value."

The area rule was kept secret for security reasons from 1952 until 1955, when first planes using the concept went into production for the Air Force and Navy. Other high-speed military aircraft under development incorporate the area rule design.

Mr. Whitcomb has been employed by the NACA since 1953 and is Assistant Head of the 8-ft. Transonic Tunnels Section of the Langley Laboratory. Earlier this year, he received an honorary degree of Doctor of Engineering from Worcester Polytechnic Institute where he was graduated in 1943. In 1955, he won the Collier Trophy and an Air Force Exceptional Service Award for his discovery.

Mr. Whitcomb has written or coauthored more than a score of research reports published by the NACA for use by the military services, other Government agencies, private industry, and educational institutions. He has contributed to many technical conferences in aeronautics and has instructed student engineers and scientists in night classes at the University of Virginia.



Richard T. Whitcomb

A paper by Mr. Whitcomb, "Zero-Lift-Drag Characteristics of Wing-Body Combinations at Transonic Speeds," was delivered at the 24th Annual Meeting of the Institute last January and was published in the June issue of the AERONAUTICAL ENGINEERING REVIEW.

Swedish Society's '56 Medal Awarded to A. M. Freudenthal

Alfred M. Freudenthal, MIAS, Professor of Civil Engineering at Columbia University, has been awarded the 1956 Medal of the Swedish Aeronautical Society.

The award was conferred after Dr. Freudenthal read a paper on "Thermal Stresses in Aircraft" before members of the Swedish Society of Engineers on August 29.

Alfred M. Freudenthal

Bo K. O. Lundberg, FIAS, President of the Engineering Group and Director of the Aeronautical Research Institute of Sweden, made the presentation at the Institute in Stockholm.

Dr. Freudenthal was graduated from the Technische Hochschule, Prague, Czechoslovakia, in 1929 and received the D.Sc. degree in Engineering in 1930.

He practiced engineering in Europe and the Near East for the following 16 years, joining the Columbia faculty in 1948 as a special lecturer. He was promoted to full professor a year later.

Allied Research Associates Is New IAS Corporate Member

Allied Research Associates, Incorporated, a research, engineering, and development firm with headquarters at 43 Leon Street, Boston, has joined the Institute as a Corporate Member.

The firm, of which Lawrence I. Levy, MIAS, is President, is engaged in research and development for the U.S. Air Force and private industry in many fields. Areas in which it is working include structural dynamics, vibration analysis and testing, aerodynamics research and aircraft operations, guided-missile design studies, atomic weapons effects, instrument design and system development, thermoelastic research, and specialized mechanical and structural design.

The company announced: "It has always been a basic policy of Allied Research to maintain the highest level of technical proficiency in its fundamental and applied research undertakings. Allied Research is well suited to assist industry and the Department of Defense in a wide area of engineering problems."

Hunsaker and Land Honored by Aeronautic Association

Two members of the Institute have been honored by the National Aeronautic Association, receiving the title of "Elder Statesman of Aviation."

They are Jerome Clarke Hunsaker, HFIAS, and Vice-Adm. Emory Scott Land, USN (Ret.), FIAS.

Dr. Hunsaker is Professor of Aeronautical Engineering at Massachusetts Institute of Technology and Chairman of the NACA.

Admiral Land is Consultant to General Dynamics Corporation, Washington, D.C.

Both received their scrolls in Washington on October 2.

Necrology

Stewart W. Cogswell

Stewart W. Cogswell, MIAS, a former instructor in aeronautics who taught the famed Gen. William "Billy" Mitchell and others how to fly, died in Daytona Beach, Fla., in August. Sixty-four years old, he was elected a Member of the Institute in 1943.

At the time of his death, Mr. Cogswell was a Consulting Engineer in Aircraft Power Plants and President of Aero Service Company, in South Daytona, Fla.

Born in Canada on New Year's Day, 1892, Mr. Cogswell was educated in Canada, graduating with a degree in Mechanical Engineering in 1911 from Nova Scotia Technical College. He also attended the University of Florida in 1942 and 1943 as a student in trade and industrial education.

In 1915–1917, Mr. Cogswell was an instructor to Army and Navy personnel, as well as civilians, at the Curtiss School of Flying at Newport News and, for the following 2 years, was Chief Instructor in Flying with the Army Signal Corps (Aviation Branch) and with the Army Air Service. It was during this 4-year period that he taught the art of flight to General Mitchell, Major Gen. Robert Olds, and Brig. Gens. St. Claire Street and Loyd Harvey.

From 1920 to 1922, Mr. Cogswell was employed as Test Pilot with the Curtiss Engineering Corporation and in 1923 began a 14-year affiliation with Harold S. Vanderbilt, performing duties in the realm of private flying and air-line survey work. Also during this period, he conducted experiments on an all-metal flying boat being developed.

At the time of Mr. Cogswell's affiliation with the Institute, he was Instructor in Aeronautics at the Volusia County Defense Training School in Daytona Beach, his duties being to give trainees preflight work and instruction in the maintenance of aircraft and power plants.

Mr. Cogswell held FAI Licenses 77 and 421, CAA Transport License 774, and CAA Aircraft and Engines License 753. He also was a member of the National Aeronautic Association, Early Birds, and Quiet Birdmen.

William M. Drake

William Martin Drake, TMIAS, a Senior Engineering Pilot with Wright Aeronautical Division of the Curtiss-Wright Corporation, was killed at Edwards Air Force Base, Calif., on August 27 during routine afterburner tests in a fighter aircraft which crashed short of the landing area after a flameout. He was 34 years old.

Mr. Drake, a native of Hugo, Okla., began his affiliation with the IAS as a Student Member in 1947 while attending Louisiana State University from which he was graduated in June, 1950, with a B.S. degree in Mechanical Engineering.

He was a former U.S. Navy pilot and flew standard carrier-based fighter aircraft from July, 1943, to August, 1946. Subsequently, he became a flight instructor and charter pilot with the Marjorie M. Gray Aero Service, Teterboro, N.J., and with North American Flying Service, Little Ferry, N.J., joining Wright in September, 1950.

Sir Richard Fairey

Sir Richard Fairey, an Honorary Fellow and Benefactor of the IAS, British aviation pioneer, and Founder and Executive Chairman of The Fairey Aviation Company Limited, died in London, England, on September 30. He was 69 years old.

Sir Richard had been suffering for several years from an ailment of the heart and chest. He had been in a London nursing home for some days under observation and treatment and underwent an operation the day before his death. The operation was completed successfully, but he suffered a respiratory failure several hours later.

Sir Richard in mid-summer surrendered the Managing Directorship of his firm because of ill health, and the Assistant Managing Director, G. W. Hall, became Managing Director. Survivors include a widow, two sons, and a daughter.

Sir Richard, born May 5, 1887, at Hendon, London, was educated at the Merchant Taylors' School and at the Finsbury Technical College (City and Guilds) where he qualified as an electrical engineer. He rose quickly in his profession, but even in those early days of aviation he displayed a keen interest in flight, devoting all spare time to models which, by 1910, had achieved the height, speed, and distance records.

In 1911, Sir Richard relinquished an electrical engineer's career and joined the group of flying pioneers at Eastchurch. After being associated with the Blair Atholl Syndicate and Dunne, he left to become Chief Engineer to Short Brothers in 1913.

Two years later, at 28, he founded his own company with a factory at Hayes, Middlesex, and a drawing office in Piccadilly. In 1916 he received his first contract from the Admiralty.

From 1922 to 1924, Sir Richard was Chairman of the Society of British Aircraft Constructors and, from 1923 to 1926, a member of the Aeronautical Research Committee.

Sir Richard was President of the Royal Aeronautical Society for 1930–1931 and 1932–1933 and was awarded the Wakefield Gold Medal by the Society for the invention and development of the wing flap. In 1942, he came to the United States as Director-General of the British Air Commission in Washington and also as a Member of the Joint Aircraft Committee, combined Aluminium/Magnesium Committee.

He was a Commandeur de l'Order de la Couronne (Belgium) and a Fellow of the City and Guilds Institute. He was created an M.B.E. (Civil) in 1920 and was knighted in 1942. He also was awarded the Medal of Freedom with Silver Palm (United States).

The efforts of Sir Richard through the years—besides introducing advanced thinking in establishing the variable camber gear and streamlining, and many other features—secured many world records for Great Britain, including the nonstop long-distance record of 5,309 miles in 1933; the helicopter speed record of 124 m.p.h. with the Gyrodyne in 1948; and, in March of this year, the absolute speed record of 1,132 m.p.h. with the Fairey Delta 2.

Among the famous aircraft which have borne the Fairey name in the last 40 years, the Fox, Swordfish, Battle, Fulmar, and Firefly will be remembered for outstanding technical merit and operational qualities.

Samuel Niedelman

Samuel Niedelman, a Member of the Institute for the last 16 years, died on June 14 in The New York Hospital after being stricken with acute leukemia. He was 50 years old.

Born in Warsaw, Poland, Mr. Niedelman was owner and President of Aviquipo Incorporated, 25 Beaver Street, New York, an aircraft and equipment exporting firm.

An aeronautical engineer, Mr. Niedelman held a Master of Science degree from Massachusetts Institute of Technology. He also was a private pilot.

Major Richard R. Sheak

Major Richard R. Sheak, USAF, MIAS, a student of engineering since August, 1955, at the U.S. Air Force In-

stitute of Technology, Wright-Patterson Air Force Base, Ohio, was found dead in bed at his home near the base on September 8. His wife, Helen, told W-P AFB authorities that she and her children had been away from home for the week end and discovered the Major dead on their return. Base doctors said his death was caused by a heart attack. He was 38.

Major Sheak joined the IAS in 1946 as a Technical Member and was advanced to Member grade 3 years ago.

A World War II veteran of 30 combat missions from Saipan with the 20th Air Force, Major Sheak was awarded the Distinguished Flying Cross and the Air Medal with four oak leaf clusters. He entered the service in 1942 and was commissioned in 1943 as a B-29 flight engineer.

Major Sheak left the service in 1946 and re-entered Tri-State College in Indiana, graduating the same year with a B.S. degree in Aeronautical Engineering. From 1946 to 1947, he worked for the Boeing Aircraft Company as a design and layout engineer in the powerplant and hydraulics groups. In the latter year, he accepted a regular Air Force commission and was returned to active duty. He was a rated flight engineer and aircraft observer.

From 1947 to 1948, he was assigned to the 4020th Air Force base unit, W-P AFB, as a flight-test engineer. Before returning to W-P AFB, he had completed a 3-year tour of duty at Strategic Air Command Headquarters, Omaha.

Major Sheak was born March 11, 1918, in North Ridgefield, Ohio.

Baldwin M. Woods

Baldwin M. Woods, AFIAS, Professor of Mechanical Engineering at the University of California, died in Berkeley, Calif., on September 7.

Born in Lampasas, Tex., on September 22, 1887, Dr. Woods held many committee posts in Government and was active in several professional societies.

He was graduated from the University of Texas in 1908 with an Electrical Engineering degree and obtained his Master of Science degree at the University of California a year later. The same University awarded him his Ph.D. in 1912.

He was President of the Academic Board, U.S. School of Military Aeronautics, from 1917 to 1919 and was U.C.'s Professor of Aerodynamics from 1919 until 1930. He also served a period as Chairman of the National Committee for the Award of W. E. Boeing Scholarships and as Chairman of the Program Committee, Pacific Coast Aeronautics Meeting.

NEWS OF MEMBERS

▸ **William F. Ballhaus** (AF) has been elected 1957 Chairman of the Aircraft Industries Association Guided Missile Committee. Dr. Ballhaus is Chief Engineer, Northrop Aircraft, Inc., Hawthorne, Calif.

▸ **Abraham Hyatt** (AF) has been appointed Research and Analysis Officer, Bureau of Aeronautics, Department of the Navy, being responsible for operation of the Airframe Design, Evaluation, and Research Divisions of the Bureau. He formerly was Director of the Research Division.

▸ **Col. Howard M. McCoy, USAF (Ret.)** (AF), has been appointed Washington Representative of the Propeller Division, Curtiss-Wright Corporation, Caldwell, N.J. He formerly was associated with The Ramo-Wooldridge Corporation.

▸ **Capt. Grayson Merrill, USN** (AF), Technical Director, Special Project Office, Bureau of Ordnance, Navy Department, has been named Navy Technical Director of the Jupiter IRBM Project.

▸ **Rear Adm. Paul E. Pihl, USN (Ret.)** (AF), who in 1941 was appointed first Director of the Aircraft Production Division of the Navy's Bureau of Aeronautics, has been elected Chairman of the Board of Hupp Aviation Company, subsidiary of Hupp Corporation.

▸ **Gajraj Bahadur Saksena** (AF), formerly Staff Specialist, Turbomotor Division, Curtiss-Wright Corporation, has joined Marsh & McLellan Inc., Chicago, as Actuary, Pensions Department.

Kenneth S. M. Davidson, FIAS, Director of the Experimental Towing Tank at Stevens Institute of Technology, has been appointed by the Department of Defense as Chief Scientific Adviser to the Supreme Allied Commander, Europe. Dr. Davidson is in Paris at the Supreme Headquarters Allied Powers Europe. His leave of absence from Stevens is expected to be about a year.

▸ **George F. Wislicenus** (M), director of the Garfield Thomas Water Tunnel, The Pennsylvania State University, was awarded the Society of Automotive Engineers' Manly Memorial Medal for 1955 on October 4 in Los Angeles at the Society's national Aero-

(*Continued on page 62*)

B. R. Teree, AFIAS, has been appointed Chief Engineer at Greer Hydraulics, Inc., Jamaica, N.Y. He formerly was Chief Engineer of the Aircraft and Special Products Divisions of The Weatherhead Company, Cleveland.

Harvard L. Hull, AFIAS, has become associated with Litton Industries, Beverly Hills, Calif., as Vice-President. Dr. Hull formerly was President of Farnsworth Electronics Company, a division of International Telephone and Telegraph Corporation.

LESTER DURAND GARDNER—Founder, Institute of the Aeronautical Sciences; Fellow, Institute of the Aeronautical Sciences, and Honorary Fellow, The Royal Aeronautical Society of Great Britain; Daniel Guggenheim Medalist; Publisher; Soldier; Public Servant; Delegate at Large in the promotion of aviation throughout the world.

In Memoriam

We of the Institute owe an incalculable debt to Lester Gardner. His was the vision to see the need for a strong and active association of aeronautical scientists and engineers at a time when air power and air transportation were selling at a discount. He realized the potential value of such a society to the national defense—a concept that needed no argument a short decade later.

For L.D.G., vision was but the prelude to action. Never one to "let George do it," he plunged into any project that intrigued him with a fervor that left his colleagues and associates gasping.

And so it was when he took the Institute under his wing. From the moment of its founding in 1932 to the day he went on inactive duty in 1946, he poured out his boundless energy, day and night, in season and out, to make the Institute the foremost organization of its kind and, through it, to keep America in the forefront of aviation development.

And so—to Lester Gardner—Hail and Farewell!

Now that he has gone, we can do no less than rededicate ourselves to the objectives to which he devoted all the years of his life.

Aviation is vastly more complicated, vastly more important today than was even imagined in the Institute's early years. All the more reason, therefore, that we should make the best possible use of this vital force that Lester Gardner nurtured, brought to fruition, and left in our hands.

The Members, Officers, and Staff of the Institute can pay their best tribute to the Founder by keeping the organization strong and alive to every opportunity to advance the arts and science of aeronautics. Through its channels, we must do what we can to make and to keep this country strong in the air—for peace or for war.

Lester Durand Gardner 1876–1956

Lester Durand Gardner, who founded the Institute of the Aeronautical Sciences in 1932, died November 23 in New York after an illness of several weeks. Burial was at Arlington National Cemetery on November 27.

Lester Gardner was an indefatigable worker for aviation. One of his last efforts in its behalf was a campaign last year to raise funds to establish the Jerome C. Hunsaker Chair at Massachusetts Institute of Technology. The drive raised $500,000. In 1954, M.I.T. had established the Lester Durand Gardner Scholarship Fund of $50,000.

It was only last summer that the National Aeronautic Association conferred upon him the title "Elder Statesman of Aviation"—the last of many honors bestowed on "Major Gardner," as he was known to thousands here and abroad. He was the third American to be made an Honorary Fellow of the 86-year-old Royal Aeronautical Society of Great Britain.

In 1944, Polytechnic Institute of Brooklyn gave him its honorary degree of Doctor of Laws. He was the recipient of the Daniel Guggenheim Medal for Aeronautics in 1947. He also was a Fellow of the Institute of the Aeronautical Sciences, honorary member of the Wings Club and The Aviation Country Club, and member of the University Club, New York, the Army and Navy Club in Washington, the Society of Automotive Engineers, American Society of Mechanical Engineers, American Legion, the Society of Colonial Wars, and Sons of the American Revolution.

He served in the Army Air Service in World War I, leaving it after the Armistice with the rank of Major.

He was educated in the Detroit public schools and was graduated from M.I.T. in 1898 with a Bachelor of Science degree. Following a year of administrative law at Columbia University, he became interested in publishing and was successively on the staffs of *The New York Times*, *The New York Herald Tribune*, *The Sun*, and *Everybody's* and *Colliers* magazines.

In 1915, he became president of the Gardner-Moffat Company, which later became the Gardner Publishing Company, publishers of *Aviation* magazine and *The Rubber Age*. The former was sold to McGraw-Hill, who continued its publication for many years before changing its name to *Aviation Week*. It was as publisher of *Aviation* that Major Gardner helped aviation through many of its growing pains.

Always interested in scientific developments, Major Gardner entered the field of radioactivity and use of radium, uranium, and thorium. He took out several patents. Following a visit to the Curies in Paris, he imported the first radium to be used for therapeutics in this country.

In 1915 he attended the first reserve officers training camp at Plattsburg, after which he and Philip J. Roosevelt published *American Defense*, a magazine that did much to arouse both official and public opinion in support of United States defense needs. While in active service in 1917–1918, he organized 89 aero squadrons for overseas service.

Major Gardner served on numerous aviation committees and official delegations appointed to further the development of aviation. He was president of the Aeronautical Chamber of Commerce of America in 1928. He also was a former president of the Technology Club of New York.

In 1932, with the help of other aviation leaders, he founded the Institute of the Aeronautical Sciences, with original headquarters at Rockefeller Center. The Institute soon became one of the greatest scientific organizations in the world, and its activities were directed by Major Gardner until his retirement in 1946

Major Gardner also founded the Aeronautical Archives of the IAS, which contains one of the world's principal aeronautical collections. He was the first Archives president.

Adaptation by Project SMART of established principles of high-speed braking and extension of their application has resulted in improved stability of high load water brakes and in development of an effective means of final arresting.

Recent Developments in Braking of High-Speed Test Vehicles

Claude A. Brosterhous* and Hugh B. Thompson**
Coleman Engineering Company, Inc.

THE URGENT NEED to develop pilot escape systems suited to the performance of high-speed aircraft has forced the adoption of specialized test methods. In this respect, the disadvantages inherent in both wind-tunnel and flight tests can, to a large extent, be overcome through the use of rocket-propelled test vehicles. Several existing rocket tracks, while not specifically designed for escape-system testing, can be adapted for this type of work. However, most of these facilities suffer from a severe limitation—the trajectories of ejected objects can be observed only from the time of their ejection to the time of their return to track level. In view of this shortcoming, Wright Air Development Center authorized the design and construction of Project SMART—Supersonic Military Air Research Track—at Hurricane Mesa in southern Utah.

Project SMART is unique among high-speed test facilities. The 12,000-ft. track terminates at the brink of an escarpment 1,500 ft. above the level of the surrounding terrain (see Figs. 1 and 2). Test objects, ejected as the carrier vehicle approaches the escarpment, can be accurately observed throughout a complete escape sequence. Catapult action, cockpit clearance, initial deceleration, separation of seat and occupant, parachute deployment, and controlled descent to the floor of the valley may be photographed and recorded.

The fact that the local topography is ideally suited to the type of test for which Project SMART was planned, however, does not imply that the associated problems are automatically solved. Propulsion, test programming, instrumentation, and data acquisition are beset with the same difficulties and to much the same degree as at other high-speed test facilities. In one respect, however, Project SMART is faced with a problem of significantly more formidable dimensions. This problem is braking.

FIG. 1.

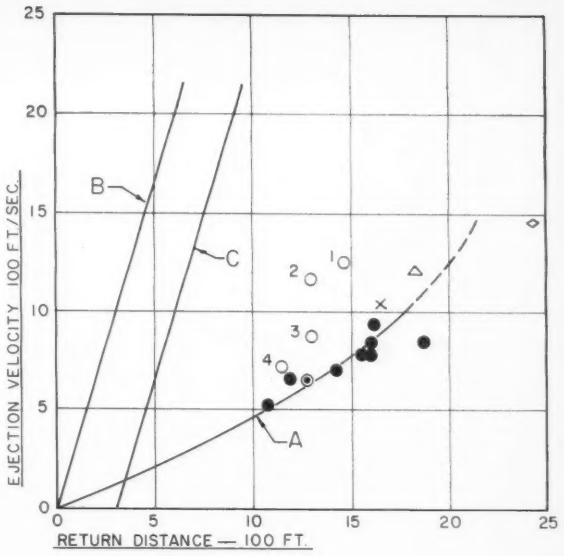
FIG. 2.

In order to assure that test objects will clear the precipice, they must be accelerated to the required speed and ejected within a given distance of the escarpment.

* Project Administrator.
** Project Technical Director.

For ejection at 1,500 ft./sec. for example, this distance is about 2,200 ft. For satisfactory photography, however, the test object should clear the precipice by some margin. Standard practice has been to allow 300 ft. beyond the end of the track itself as a clearance margin. (The track itself actually terminates 50 ft. short of the precipice.) During the process of catapult action and rocket burnout the vehicle travels approximately 450 ft. Subtract these 750 ft. from the original 2,200 ft., and 1,450 ft. of track remains in which to decelerate and stop the vehicle. If constant braking could be applied, this would imply a load of only about 25*g*. However, in the present state of the art, constant braking loads are impossible to achieve at the speeds under consideration. The performance of conventional water brakes deteriorates so sharply at low speeds that successful on-track recovery of the vehicle presents serious difficulties. In meeting these difficulties, Project SMART has been forced to extend the technology associated with high-speed braking. The stability of high load water brakes has been significantly improved, and an effective arrester gear suitable for final braking has been successfully developed.

The extent of the breaking problem at Hurricane Mesa is illustrated in Fig. 3. The curve A shows the relation between vehicle speed at the instant of ejection and the distance traversed before the ejected object returns to track level. The points associated with this curve were derived from tests of standard F-84 and F-86 ejection seats carrying anthropomorphic dummies. Controls were sequenced for lap-belt release 1 sec. after catapult initiation and for parachute deployment 1 sec. after lap-belt release. For tests in which seat and dummy separation was successful, the point plotted represents the trajectory of the dummy. The degree of scatter shown by these points can probably be fully accounted for by the random tumbling of unstabilized seat-dummy combinations.



LEGEND:

- ● SUCCESSFUL TESTS. 1 SEC.–1 SEC. SYSTEMS.
- 1 ○ CATAPULT RUPTURED.
- 2 ○ CATAPULT RUPTURED AND DUMMY CAUGHT ARM IN COCKPIT.
- 3 ○ PREMATURE SEPARATION BETWEEN SEAT AND DUMMY.
- 4 ○ NO SEPARATION BETWEEN SEAT AND DUMMY.
- △ PARACHUTE PARTIALLY DEPLOYED WHEN DUMMY ENTERED WATER BRAKE SPRAY.
- ◇ SEAT DISINTEGRATED IN FLIGHT.
- ✕ PARACHUTE FULLY DEPLOYED BEFORE RETURN TO TRACK ELEVATION.
- ◉ 2 SEC.–2 SEC. SYSTEM. 2 SEC. TO LAP BELT RELEASE; 2 SEC. TO PARACHUTE DEPLOYMENT.

FIG. 3. Ejection seat tests, dummy trajectories.

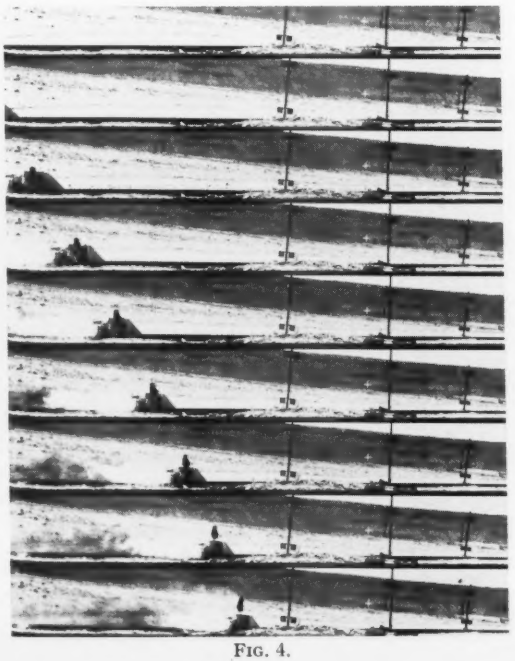


FIG. 4.

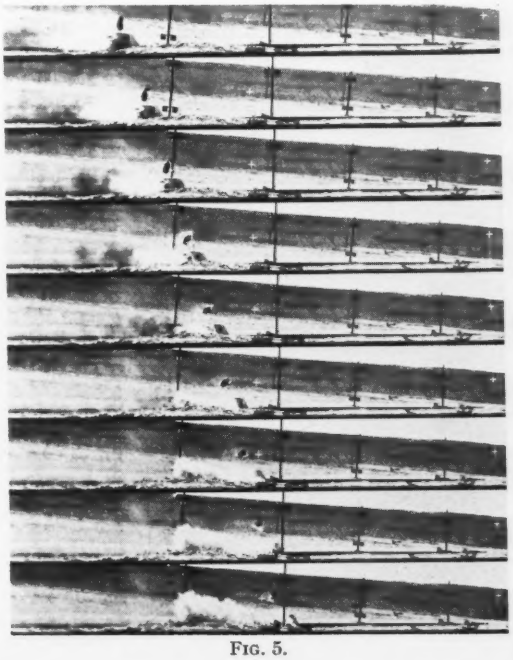


FIG. 5.

The line B indicates the distance traversed by the vehicle between the instant of catapult initiation and the time when the ejection seat and dummy are wholly clear of the cockpit. Line B is translated 300 ft. to form line C; this takes into account the 300-ft. clearance of the end of the track required for satisfactory photographic records and to allow a reasonable real scatter from curve A. At a given speed, therefore, the distance available for braking is equal to the difference between the abcissas of curves A and C.

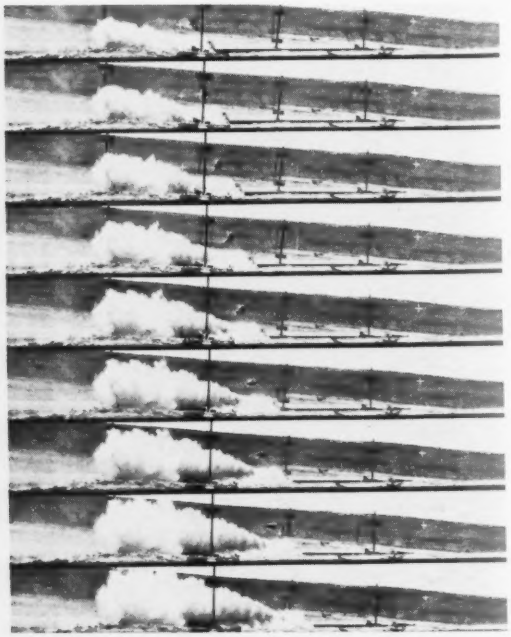


FIG. 6.

It is notable that curves A and C approach an equal slope at approximately 1,700 ft./sec. This would tend to indicate that, beyond this point, the available braking distance would no longer increase as speed increased. The braking loads for speeds greater than 1,700 ft./sec. would increase as a function of velocity squared. Two factors, however, promise relief from this difficulty. (1) The escape systems required at these speeds will be more efficiently streamlined than current ejection seats; therefore, it is reasonable to assume that their trajectories will be flatter. (2) The known limitations in parachute performance clearly indicate that, for high-speed escape systems, parachute opening must be considerably delayed.

If the test vehicle is to be arrested by means of a water brake—and for the loads and velocities under consideration no reasonable alternative is apparent unless completely reliable vehicle recovery by parachute can be achieved—further difficulties are introduced by the effects of spray. While the geometry of the track at Hurricane Mesa requires that the vehicle be braked immediately beneath the test object trajectory, acquisition of valid data and the requirements of photography demand that the trajectory be at all times clear of the spray generated by the brake. The extent of this difficulty is illustrated by Figs. 4–10. These photographs were taken by a Bowen camera at 90 frames per sec. The speed of the vehicle as it entered the braking area was 1,175 ft./sec.

Having outlined the scope of the problem, it is appropriate to review the methods of solution applied at Project SMART and evaluate the extent to which they have been successful.

Early in the design phase it was appreciated that the upper load limit of existing water brakes was limited by

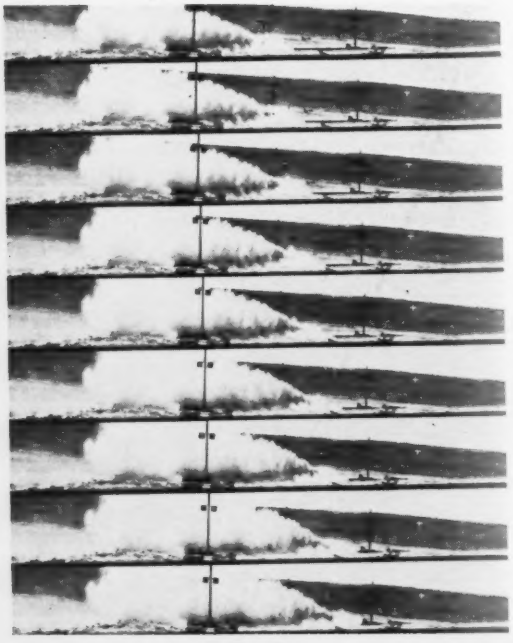


FIG. 7.

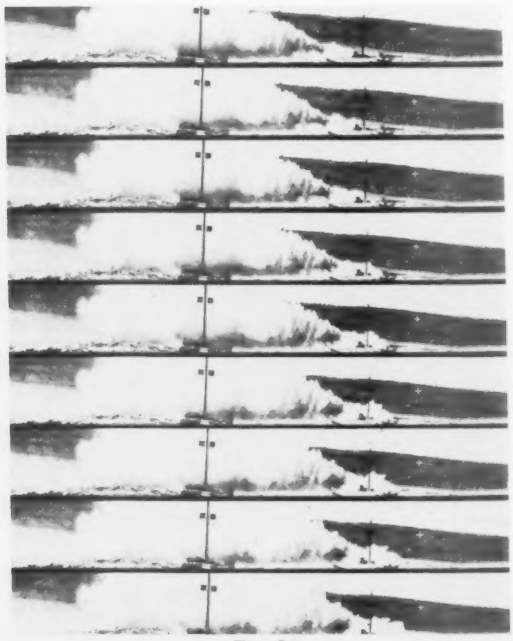


FIG. 8.

dynamic instability arising from deflection and oscillation of the support structure. Attempts to overcome this barrier through the use of damping devices had not met with notable success. The alternate course of increasing the stiffness of the support structure—that is, the vehicle—had led to a dilemma. Increased rigidity implied greater weight, and as weight increased so did the braking load. The solution proposed at Project SMART was to increase the stiffness by means external to the vehicle.

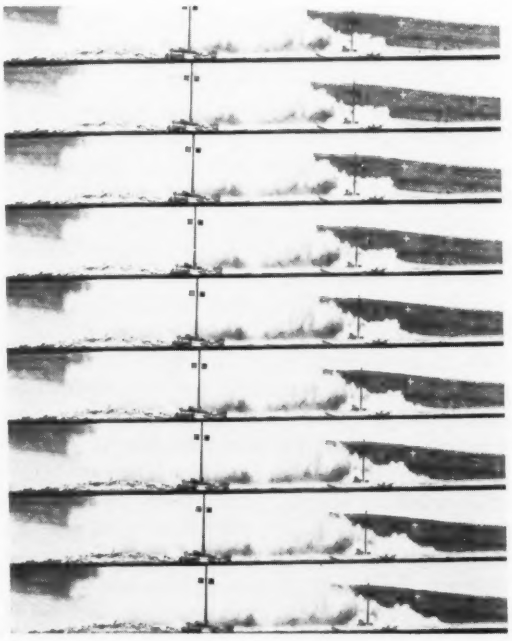


FIG. 9.

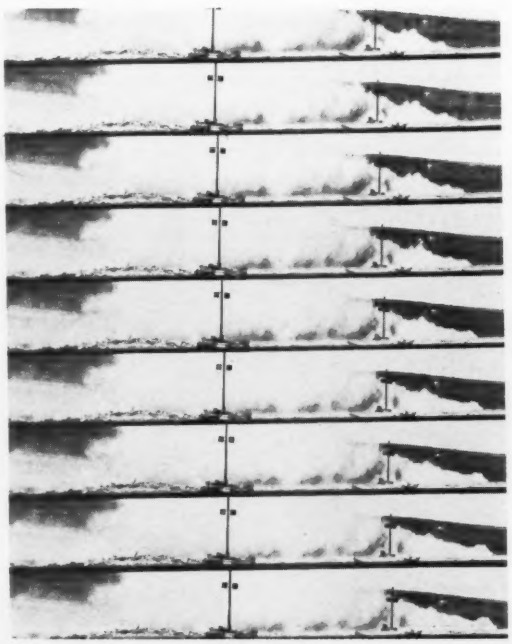


FIG. 10.

In the operation of any high load water brake the development of some vertical load is inevitable. It is this load that is chiefly responsible for the structural deflections leading to instability. At Project SMART it was decided to design the brake so that the vertical load acted only in the downward direction. By means of a shoe mounted to the bottom of the brake scoop this load could be transmitted directly to a third rail firmly anchored to the concrete track girder. Deflection of both brake and vehicle would be significantly reduced and the upper limit of stable operation correspondingly raised.

The third rail used at Project SMART is a heavy 10-in. structural-steel channel. This is centrally mounted between the two track rails and coextensive with the water brake trough. The channel section was chosen not for structural reasons but for ease of alignment.

The water brake at SMART is a programed type similar to that used at Edwards Air Force Base. The track is graded so that immersion of the brake scoop is progressive. In addition, provision is made for the installation of frangible dams so that any pattern of stepwise changes in immersion can be produced. In order to conform to the programed grade of the track, the third rail was supported on special fixtures and accurately adjusted in the vertical plane. When the required alignment had been established, the rail was anchored to the track girder with a continuous concrete support. In use, a steel shoe fitted to the bottom of the brake scoop engages this rail as the vehicle approaches the brake trough; engagement is continuous throughout the braking period. Fig. 11 shows the third rail and its concrete support. Figs. 12 and 13 show two views of brake scoops in contact with the rail.

Two different configurations of water brake have been used at Project SMART. Both turn the water through approximately 180° of arc—one in the vertical plane, the other in two symmetrically opposed planes canted slightly upward from the horizontal. The latter configuration, based on a design originated at Edwards Air Force Base, is shown in Fig. 12.

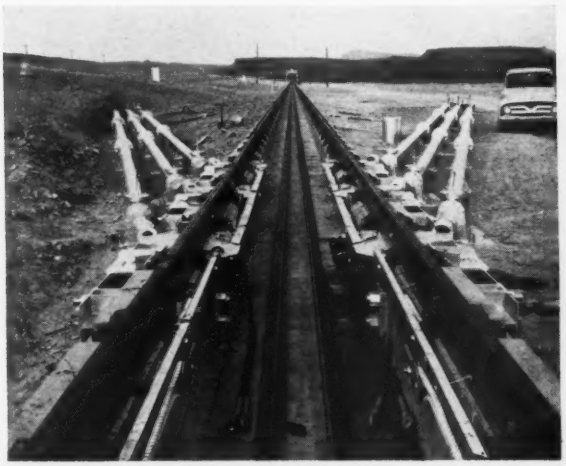


FIG. 11.

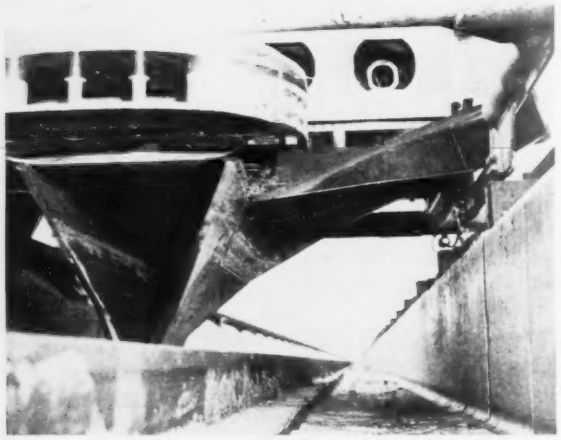


FIG. 12.

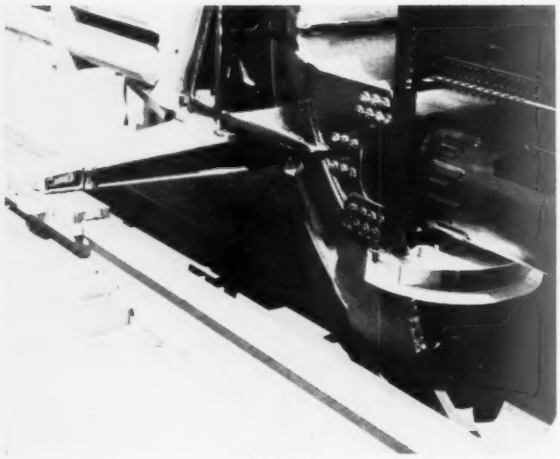


FIG. 13.

The horizontal-return brake shown in Fig. 12 is a 4130 steel weldment. A non-heat-treated model of this brake has been successfully tested at loads up to 130,000 lbs. with no signs of incipient oscillation or instability. In the heat-treated condition (150,000 psi min.) it is designed to develop a braking load of 350,000 lbs.

Some trouble has been experienced with this brake in the development of excessive spray. This was apparently caused by water, deflected by the scoop entry, impinging on parts of the brake and vehicle structure and being deflected upward. Two remedies have been applied in the attempt to lessen this difficulty: The flanges have been removed from the channel section third rail, changing it to a flat plate; and gusset-like shields have been installed in the curves formed by the return conduits of the water brake itself. Some reduction in spray has been achieved by these methods, but the problem is still troublesome.

The vertical-return water brake is shown in Fig. 13. This brake is designed as part of a vehicle using liquid-propellant rockets. In order to achieve maximum structural efficiency, the propellant tanks are designed to transmit both thrust and braking loads. Though the vehicle shown in Fig. 14 uses dry-propellant rockets, it closely simulates the structural geometry of the liquid-propellant vehicle now under construction.

The brake consists of a vertically oriented semicircular steel channel. The scoop, which has beveled edges, is substantially V shaped. In order to achieve a satisfactory compromise with the various load conditions anticipated, the main part of the return conduit has a section approximately resembling the narrow end of an ellipse. Satisfactory contact between the support shoe and the third rail is assured by tilting the bifurcated exit duct upward at approximately 5°.

This brake is fabricated in 4340 steel, and heat-treatment to 190,000 psi is required. In this condition it is designed to develop a braking load of 681,000 lbs. Thus far, however, the brake has been tested only to a load of 300,000 lbs. This load was developed with rela-

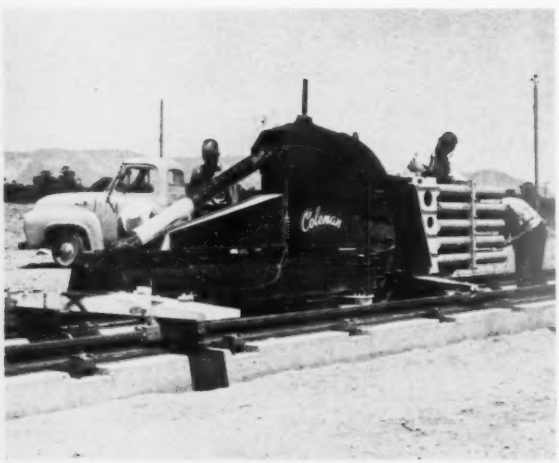


FIG. 14.

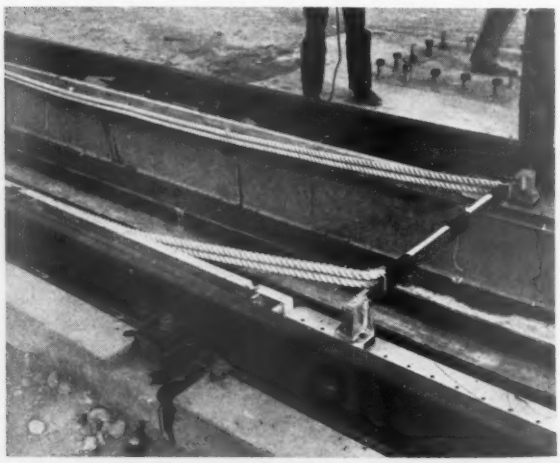


FIG. 15.

tively complete stability. In this test the vehicle was accelerated to 720 ft./sec. and braked to a complete stop in a total of 500 ft.

On a conventional test track, a water brake may fulfill all braking requirements even though the force developed falls off sharply as speed decreases. Usually, a sufficient length of track can be provided to allow vehicles to coast to a complete stop. At Hurricane Mesa, however, this is not the case. A vehicle that is still traveling at several hundred ft./sec. when full of water will experience a drastically reduced braking load as the vehicle slows down from this point on. As this will very shortly exhaust the available track, the vehicle will disappear over a 1,500-ft. precipice. For this reason a positive arrester gear capable of braking the vehicle to a complete stop was developed for Project SMART by the All American Engineering Company.

This equipment, which is shown in Fig. 11, comprises three pairs of tapered tubes symmetrically disposed with respect to the track centerline. The tubes, which are filled with water, house loosely fitting conical pistons. Cables, engaging an arrester hook mounted on the vehicle, are led through a series of pulleys housed in the track girder and attached to the pistons. As the vehicle engages the arrester gear, the pistons are pulled through the tapered tubes in the direction of decreasing diameter. The dynamic resistance of the water flowing around the pistons thus dissipates the kinetic energy of the moving vehicle. Fig. 12 shows the installation of the arrester hook on the horizontal-return water brake and Fig. 13 on the vertical-return brake. The cable pickup arrangement is shown in Fig. 15. The steel cables associated with the pistons are attached to a pair of nylon cables supported between the track rails. Nylon is used for the pickup cables in order to absorb the initial impact.

The braking force developed by the arrester gear is taken out through the foundations of the tapered tubes. The couple developed between the pairs of cable guide pulleys is reacted by the concrete track girder.

The use of three pairs of tubes gives the arrester gear considerable flexibility. One pair of tubes will accommodate vehicles weighing up to 6,000 lbs. As each additional pair increases the capacity by this amount, it is possible to brake vehicles weighing up to 18,000 lbs.

Since the problem of braking is basically one of energy dissipation, velocity is a more important factor than vehicle weight. The Project SMART arrester was designed to stop vehicles with an entry velocity of 200 ft./sec. in a distance of 100 ft. This is equivalent to an average deceleration of approximately 6*g;* however, peak loads as high as 20*g* are developed during normal operation. As a safety factor, the original design considered the possibility of occasional entry speeds as high as 250 ft./sec. In this connection it is notable that, on one occasion when rocket programing failed, a vehicle entered the arrester at 350 ft./sec. Except for a slight stretching of the cables, a safe stop was achieved without damage to either the vehicle or the arrester.

Because of its unusual configuration and the test program in progress, Project SMART has been faced with unique demands with respect to braking. By adapting known principles and extending their application beyond the established state of the art, most of these demands have been successfully met. Test results indicate that externally stabilized water brakes may reasonably be expected to produce forces as high as several hundred thousand pounds without oscillation. An effective means of final arresting, readily adaptable to a variety of vehicle weights and configurations, has been satisfactorily developed. Among the difficulties still calling for concentrated attention, the suppression of water spray in the braking area is particularly troublesome.

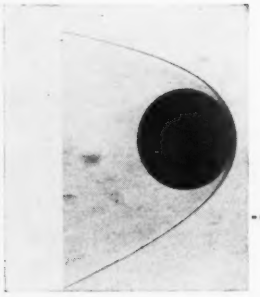
Symposium on Digital Computing in the Aircraft Industry

New York University—Jan. 31–Feb. 1, 1957

A joint symposium, sponsored by New York University, Mathematics Department, Research Division; International Business Machines Corp.; Society for Industrial and Applied Mathematics; and the Institute of the Aeronautical Sciences, Inc., will be held at the Gould Student Center, N.Y.U. College of Engineering Campus, University Heights, N.Y. This symposium will cover applications of the digital calculator in Aerodynamics; Dynamics; Structures; Statistics and Probability; Operations Research; Logistics; and Nuclear, Design, and General Computations.

Please contact one of the following individuals if you wish to attend: Arnold S. Wolf, IBM Corp., 590 Madison Ave., New York 22, or Dr. Max Woodbury, N.Y.U., Research Division, 401 W. 205 St., New York.

The use of small-scale models, shock tubes, and hypersonic wind tunnels in investigations of hypersonic data.



Experimental Hyperballistics

H. H. Kurzweg* and R. E. Wilson**
U.S. Naval Ordnance Laboratory

The Problem

HYPERBALLISTICS is a relatively young branch of the aerodynamic sciences. Relatively new, therefore, is the development of hyperballistic facilities and their instrumentation which are both quite different from the tools used in low-speed and supersonic experimentation. We are now in a stage of the development where the basic knowledge of hypersonics is rapidly increasing and where the opinions about what is right and what is wrong with the theoretical and experimental results are still frequently changing with new discoveries.

In spite of the fact that many of the problems are still unsolved, an attempt shall be made in this report to discuss the status of the art and to summarize the highlights of various experimental approaches which have contributed, so far, more or less successfully to the understanding of hypersonic phenomena.

Aerodynamicists and ballisticians have developed two principally different methods for model testing to get information for the design of their vehicles. The models are either subjected to the impact of air streams in wind tunnels, shock tubes, shock tunnels, etc., or they are accelerated to the desired speed by a gun, rocket, or some other accelerator and fired in a range through air or any other gas at rest under usually well-defined conditions. Both methods have also been combined by firing models from a gun in wind tunnels.

None of the methods by itself gives in general all the answers which one needs to work on hypersonic vehicles. Usually a multitude of information is needed for the calculation of the shape, performance, and behavior of the vehicle under design.

In this respect, the high-speed computing machines have become extremely powerful tools in hypersonic investigations. They are becoming increasingly more a part of the experimental techniques. They allow not only faster evaluation of the tests and, therefore, better test planning but also serial calculations with an otherwise impossible number of variations of assumed coefficients. Such calculations can closely simulate even full-scale tests if the aerodynamic conditions are already reasonably well known. At hypersonic speeds, how-

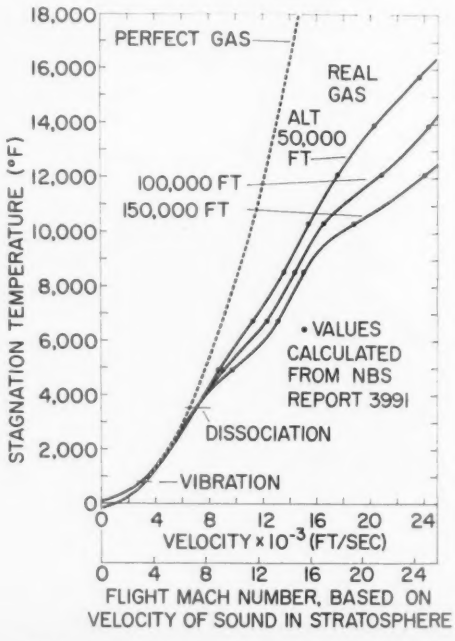


FIG. 1. Real gas effects on stagnation temperature, blunt body.

Presented at the Aerodynamic Heating: Aerodynamic Aspects Session, National Summer Meeting, IAS, Los Angeles, June 18–21, 1956.

* Associate Technical Director for Aeroballistic Research, NOL.
** Chief, Aerophysics Division, NOL. Now, with Chance Vought Aircraft, Incorporated, Dallas, Tex.

ever, the cookbook does not yet exist from which all necessary coefficients can be drawn.

The Hypersonic Tunnel

It will be assumed in this report that the essential design features of "conventional" hypersonic wind tunnels are known. In short, these are modified supersonic tunnels with compressed supply air which is preheated to avoid air liquefaction. The supply pressure is usually between 50 and 150 atmospheres to obtain reasonable Reynolds Numbers with relatively small models.

Let us briefly recall in what respect these tunnels can simulate free-flight conditions. In Fig. 1 the stagnation temperature is plotted for vehicles flying up to Mach Number 24 at various altitudes. The perfect gas curve, which indicates the parabolic increase of the stagnation temperature with speed, does not describe the actual situation because of the real gas effects at high temperatures: vibration, dissociation, electronic excitement, and ionization. These effects are due to added degrees of freedom of internal molecular motion to which the compression and friction energy is distributed in the same manner as it is at lower temperatures to the external translation and rotation of the molecules. These effects are influenced by the composition of the gas but are mainly functions of temperature and pressure and vary therefore with altitude. The calculations are made with the newest calculated properties of oxygen and nitrogen under equilibrium conditions collected by the Bureau of Standards.[1] For example, at Mach 10, the perfect gas gives 8,000°F., whereas the real gas, dependent on altitude, has considerably lower stagnation temperature. The comparison with the conditions in conventional hypersonic wind tunnels shows the situation. Since the tunnels can be operated up to approximately 1,500°F. without running into tremendous difficulties with heaters and cooling of the nozzle, this type of wind tunnel does not give the same state of the air as it is in the vicinity of missiles in free flight at Mach 10 and higher. This apparent shortcoming of the hypersonic tunnels is principally not incorrigible because wind-tunnel investigators are used to apply similarity laws in model testing anyway. To the similarity parameters attributed to compressibility, viscosity, and heat conductivity, new similarity parameters have to be added which take care of the internal molecular forces.

It is in general extremely difficult to obtain in any model test facility similarity in all respects with the full-scale conditions. Fortunately there are cases where this is not necessary because the similarity parameters are not always simultaneously equally important. Usually one of the facilities is better suited than the other to study the effect of one particular similarity parameter without making mistakes by neglecting the others. For example, in a hypersonic tunnel of 16 by 16 in., with 150-atmosphere supply pressure and 1,500°F. supply temperature, similarity in Mach Number up to 10 can easily be obtained by the geometric shape of the nozzle.

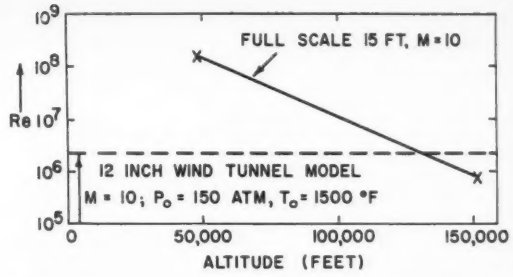


Fig. 2. Comparison of the Reynolds Number obtained in a hypersonic wind tunnel with that of a free-flight vehicle at various altitudes.

Reynolds Number similarity can be achieved for bodies at extremely large altitudes, as can be seen in Fig. 2. However, neither the correct rates of heat transfer nor the real gas effects can be simulated at this Mach Number. These tunnels work close to the other low-temperature end of the ideal gas region. Their static temperature is just above the liquefaction temperature, and at their stagnation temperatures only a small amount of vibration can be excited.

Since, however, the free-flight curve in Fig. 1 indicates relatively little change of stagnation temperature up to Mach Number, say Mach 8, similarity in Mach and Reynolds Numbers seems to be the only necessary condition. The small real gas effects might be sufficiently predictable up to this Mach Number, and the effects of the restricted low heat-transfer rates on the heat-transfer coefficients and friction can probably be extrapolated from the lower rates without great mistakes. More has to be learned about their correction from investigations in other facilities.

The Hypersonic Shock Tunnel

There is no doubt that the supply air of the conventional hypersonic tunnels cannot be heated to the free-flight temperatures at Mach Number 10 and above by a heat exchanger with combustion or electricity for minutes of operation. However, extremely high wind speed can be produced, although only for very short times, by adiabatic compression of the air or any other gas by a piston or a shock wave. The higher the pressure ratio in front and behind the diaphragm, the higher the speed and the stagnation temperature of the gas following the shock wave which is put in motion after the diaphragm has burst. With pressure ratios of 20 to 30,000 in such gunlike shock tubes, gas speeds of 15,000 ft. can be obtained without major difficulty. The blowing times of these hypersonic winds are in the order of 1 millisec. which obviously does not allow much time for measurements. But, in spite of the extremely short times, test methods have been devised to observe the flow and to measure heat transfer and pressure.

Although the absolute speed of the gas is high, the Mach Number is small—in the order of Mach Number 2—because of the high sonic velocity in the hot gas. With respect to similarity, the right temperature with its effect on the real gas properties and heat transfer

exists, but the Mach Number is wrong. This condition is just opposite to that of the conventional wind tunnel.

In order to obtain high Mach Numbers also, expansion nozzles in which the gas cools down when it is accelerating have been added to the shock tubes. Fig. 3 shows the history of the flow past a cylinder at Mach 12.5 in xenon gas on the NOL shock tunnel. The tunnel has a diameter of 20 mm., a length of 15 ft., and an expansion nozzle of 12 in. in diameter. The total running time is 0.2 millisec. From the study of such high-speed camera pictures (100,000 frames per second, which are approximately 10 microsec. apart), it was concluded the flow is stationary during about 40 microsec., a relatively small portion of the total time of 200 microsec. Much effort has been spent to develop test techniques to measure temperatures and pressures at these extremely short times of blow, but the problems have not yet been entirely solved. Resistance thermometers painted or evaporated on glass surfaces gave under certain conditions, especially at the stagnation point of blunt bodies, apparently good results which agree with calculations.

Such shock tunnels have been used so far, in general, for basic investigations rather than for direct model testing. For example, they were used for measuring the properties of gases such as the heat conductivity where at these extremely high temperatures no experimental results exist so far. Fig. 4 shows Smiley's first results[2] of his measurements of the heat conduction coefficient up to 2,500°C. The agreement with the calculation appears to be good. On the same figure can be seen an actual oscilloscope trace of the temperature increase of a flat piece of pyrex glass perpendicular in the air stream which was used for these measurements. Each interval is 1 microsec.

In general one has to learn more about the condition of the air stream and its properties at higher temperatures before actual model tests give results which can be reliably converted to full-scale bodies. This is especially true for the type of shock tunnels with expansion nozzles for high Mach Number. Not only the geometric shape of the nozzle but also the cycle of the real gas effects connected with the individual relaxation times of the various phases of excitement—and the contamination of the air by dust, diaphragm particles, etc.—enter

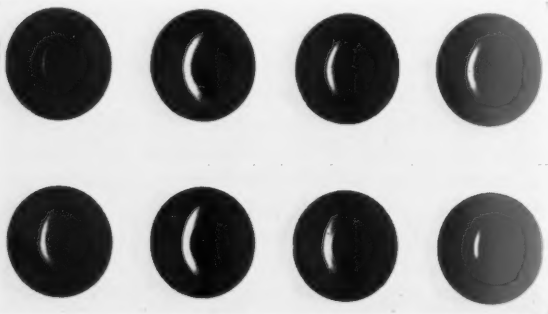


FIG. 3. History of the flow over a cylinder in the NOL hypersonic shock tunnel (interval, 10 microsec.)

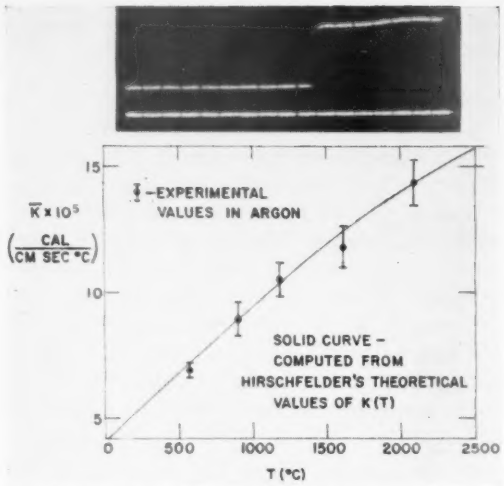


FIG. 4. Heat conductivity vs. temperature measured in the NOL hypersonic shock tunnel.

the process of building a uniform and well-defined air stream. The shock tube without expansion avoids some of these troubles and should, therefore, be considered the more reliable tool—especially in cases where the Mach Number as a similarity parameter can possibly be neglected (as shown later)—for example, at the nose of blunt bodies. In cases like the investigation of flat plate flow—especially for studies of stability and transition of boundary layers where the temperature profile and the connected density and viscosity distribution are very much Mach Number dependent—more realistic results can be expected from shock tubes with expansion nozzles after the flow in such nozzles has sufficiently been analyzed and corrected.

THE FREE-FLIGHT WORK IN THE RANGES

As pointed out before, neither from wind tunnels nor from shock tubes alone can complete information for a full-scale design of an extremely fast vehicle be expected. Data from free-flight facilities are needed which can come, in principle, to any desired degree close to the full scale. Telemetered data from rocket tests and results from precision ranges in which models can be fired as projectiles have contributed considerably to our present knowledge in ballistics, and they are used increasingly for the study of hypersonic phenomena.

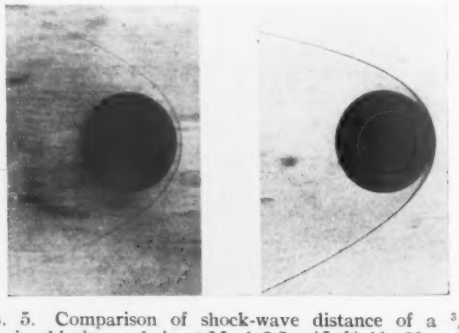


FIG. 5. Comparison of shock-wave distance of a $^3/_{10}$-in. sphere in chlorine and air, at Mach 8.5. (*Left*) Air, 20-mm. Hg. (*Right*) Chlorine, 50-mm. Hg.

The firing ranges offer basically the following possibilities:

(1) Model investigations can be made at the same absolute speed as that of the full-scale vehicle. This automatically assures similarity in Mach Number and temperature level.

(2) Models can be fired in a controlled atmosphere of selected pressures to simulate Reynolds Number or altitudes.

(3) Models can be fired for basic investigations in gases other than air.

(4) The dynamic behavior of models can be studied—for example, damping characteristics for which the observation time is too short in shock-tube tunnels.

Of course, the following obvious prerequisites are necessary to use these ranges for hypersonic studies:

(1) Guns which fire at speeds above 10,000 ft./sec.

(2) Test techniques which allow measuring characteristics of an extremely fast and relatively small projectile during approximately one tenth of a second along a distance of several hundred feet—a task which at first seems to be considerably more difficult than the instrumentation of wind tunnels and shock tunnels.

The Investigations in Gases Other than Air

Considerable progress has been made during the last years in solving the problems of hyperballistic guns and short-time instrumentation. A few years ago, no gun was readily available to fire in air projectiles large enough at Mach Number 10 and higher to study flow fields around them. To overcome this problem, ordinary guns with greatly increased pressure were fired at 7,000 to 8,000 ft./sec. in gases other than air. Freon was originally used for such tests, and Mach Numbers in excess of 10 were obtained. But freon is a complex gas, and the interaction between its internal molecular forces is quite involved. Gases like bromine or chlorine are simpler in structure and, therefore, more easily adaptable to theoretical approaches. They are diatomic gases whose two atoms are less strongly attached to each other than the two atoms in the nitrogen or oxygen molecule—the two main components of air. Therefore,

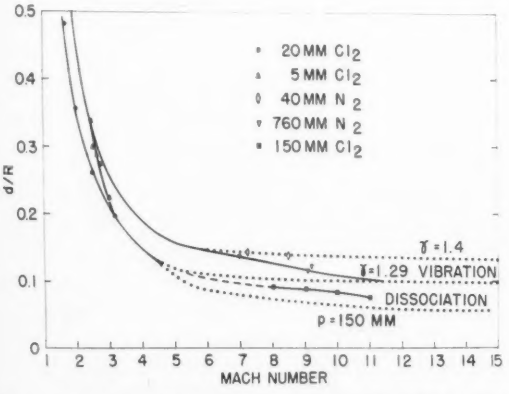


FIG. 6. Shock-wave distance, d/R, of spheres vs. Mach Number, M, indicating real gas effects.

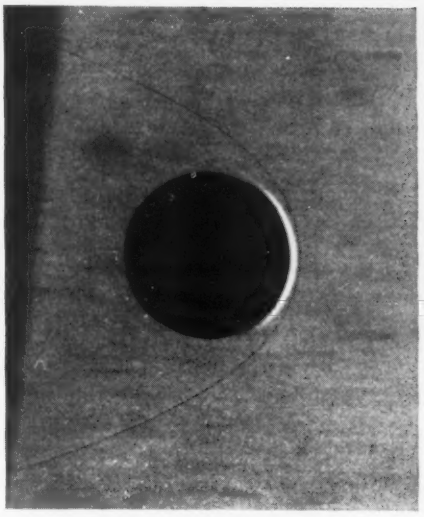


FIG. 7. Sphere in xenon at Mach 17.

the excitement of the two real gas effects, vibration and dissociation, is bound to occur at lower temperatures in chlorine or bromine than in nitrogen or oxygen. The equivalent effect in any two different diatomic gases will place at equal ratios of $h\nu/kT$, the similarity parameter of this process, with h and k Planck's and Boltzmann's constants respectively, ν the frequency, and T the temperature. When this ratio assumes the value one, $1/e$ molecules are in the excited state—for example, at T = 3,300°K.—$1/e$ molecules of N_2 are vibrating. The equivalent temperature for O_2 is 2,300°K. and that of Br_2 and Cl_2 470°K. and 810°K., respectively. A similar value of $h\nu/kT$ can be defined for the other real gas effects.

The results of such investigations are demonstrated in Fig. 5 where two spheres of $^3/_{10}$ in. were fired in a small range first filled with chlorine and then with air, both at approximately the same Mach Number of 8.0. The vibrational model of the air molecule is not excited, but that of the chlorine is. Since the ratio of the specific heats, γ, changes from 1.4 to 1.29 when the gas is fully excited, the front shock wave moves closer to the sphere in accordance with theoretical predictions. Using this method of measuring shock-wave distances on spark photographs, it was possible for the first time to obtain quantitative information of the effect of vibration on the flow field of a free-flight projectile. Fig. 6 shows the shock-wave distance for the nonexcited (γ = 1.4) and fully-excited (γ = 1.29) diatomic gas as a function of Mach Number which was obtained by J. Eckerman[3,4] at NOL. It can be seen that the data for chlorine at lower Mach Numbers, where the temperatures are still low, are on the γ = 1.4 curve, whereas at higher Mach Numbers the transition to the γ = 1.29 curve takes place. It can be demonstrated in such a test that this transition is also a function of the pressure. For example, a few points are plotted which were obtained under higher pressure and lie therefore on the γ = 1.29 curve already at low Mach Number. The correspond-

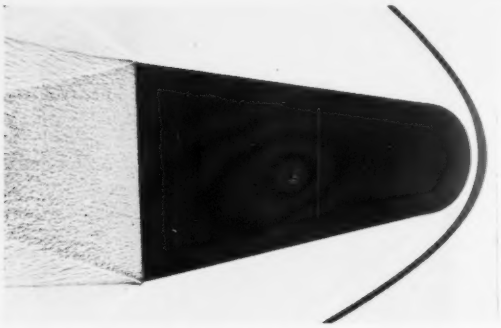


FIG. 8. Shadowgraph of the conical nose of a projectile showing transition of boundary layer.

ing transition in nitrogen can be recognized at the higher Mach Numbers.

From the length of the transition region, estimates of the relaxation time of the process have also been made which are in good agreement with shock-tube results in chlorine obtained by spark-interferometer pictures.

Also the other real gas effects, dissociation, electronic excitement, and ionization have been attacked by this method; however, not many quantitative results have been obtained so far. A few points indicate the further decrease of the shock-wave distance with beginning dissociation. Pictures like Fig. 7, spheres in xenon gas at Mach 17, have been obtained using a rotating mirror to minimize blur and distortion. It can be seen that the position of the shock wave even at this high Mach Number can be measured very well. The region of electronic excitement in the vicinity of the stagnation point and the region of relaxation where the gas is not yet luminescent can clearly be noticed.

The Large Pressurized Range

The results of the real gas effects on the shock-wave distance have been obtained with relatively small models—$^{3}/_{10}$-in. spheres of nylon. It is rather obvious that the much needed detail studies of boundary layers, especially their transition from laminar to turbulent, cannot be made on models of this small size. It was, therefore, desirable to use the large NOL Pressurized Ballistics Range where guns up to 50-mm. caliber can be fired.

As mentioned before, the speed of these large conventional guns is relatively low. The highest muzzle velocity which could be expected with them was 4,000 ft./sec., three to five times lower than needed for Mach Number similarity in the hypersonic speed region. In spite of this, typical hypersonic conical bodies with sharp and blunt noses were fired, and investigations were made of boundary-layer transition as effected by pressure gradients, surface roughness, angle of attack, and temperature. The tests were made at pressures between $^{1}/_{100}$th and 6 atmospheres—that is, a variation of 600:1 in Reynolds Number per foot. Excellent spark-shadowgraph pictures such as in Fig. 8 were obtained on which laminar and turbulent boundary layers can be clearly distinguished.

Some of these tests that were originally planned to investigate boundary-layer transition at low free-stream Mach Numbers might come extremely close to the hypersonic case, especially when bodies with very blunt noses are involved:

(1) If one calculates the local Mach Number distribution along a spherical nose to the angle corresponding to the half apex angle of the continued cone, one notices that the local Mach Number at the surface does not change much even when the free-stream Mach Number varies considerably. It can be seen in Fig. 9 that the local Mach Number up to rather large cone angles is practically the same if the projectile flies with Mach 22 or with Mach 5.

(2) Even if real gas effects are present, assuming they are in an equilibrium state, the Mach Number distributions without dissociation and dissociated air show practically no difference (see Fig. 10).

(3) If one calculates the local Reynolds Numbers, one finds that there is practically no change either in the whole range between Mach 5 and 22 (see Fig. 11). The local Reynolds Number per foot in the range at Mach 5 and in the atmosphere at Mach 22 at equal pressures is therefore the same. Hence this important parameter for the boundary-layer transition is simulated with the low-speed gun.

(4) If one puts any weight on the application of flat-plate stability theory on blunt-body boundary layers with heat transfer, one finds that the blunt body during the short time under the range conditions lies always, because of the low Mach Numbers, on the favorable side with respect to the transition (see Fig. 12).

The Helium Gun

In spite of the fact that valuable information can be obtained by firing suitable projectiles with lower speeds in the ranges or by firing them in gases other than air, high-speed guns are needed. The influence of the real gas effects and their relaxation cycles on the aerothermodynamic coefficients have to be checked on larger projectiles at hypersonic free-stream Mach Numbers in nitrogen and oxygen.

Several approaches have been made to accelerate projectiles to speeds beyond the reach of conventional powder guns. Ideally suited for range work would be an electric accelerator since no contamination of propellant gases would enter the test section. Attempts have been made in this direction, but, so far as is known, none of the designs fired projectiles in the order of 10,000 ft./sec.

More familiar to the ballistician is the idea to improve the conventional powder guns. It can easily be shown in what direction changes have to be made in order to obtain higher speed. Since the process of gas expansion in guns is basically the same as that in shock tunnels, the same equations can be applied in both cases. The projectile-piston of the gun is equivalent to the gaseous, minimum mass piston, the contact surface, in the shock tube. The work which is done in pushing

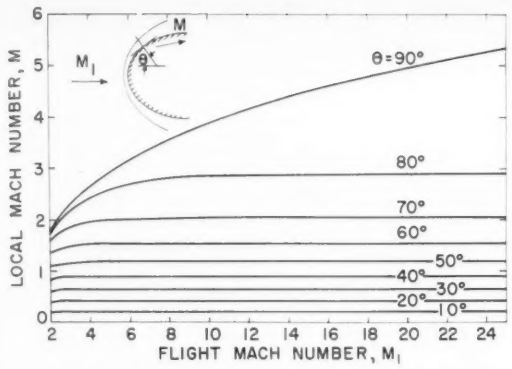


FIG. 9. Mach Number distribution over blunt bodies, perfect gas.

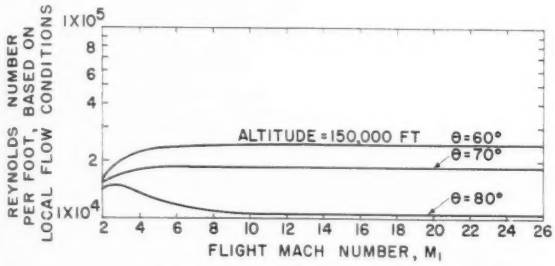


FIG. 11. Effect of flight Mach Number on local Reynolds Number, blunt body, perfect gas.

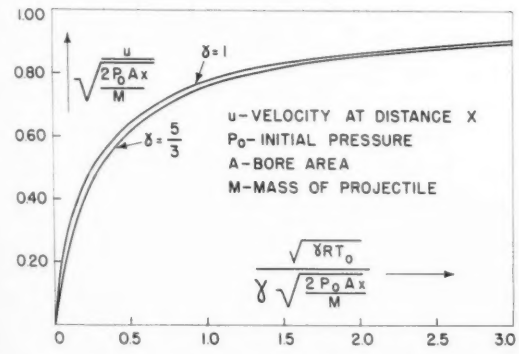


FIG. 13. Dimensionless speed of projectiles vs. dimensionless sonic speed of driver gas.

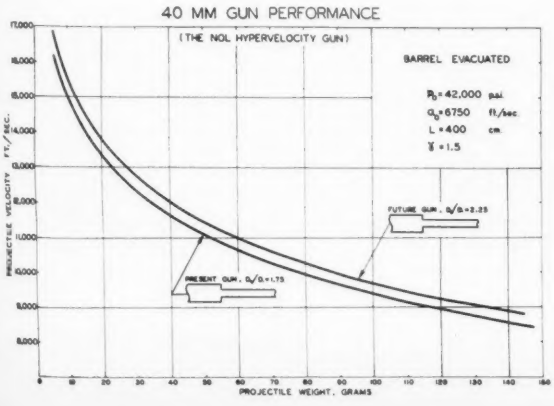


FIG. 14. 40-mm. gun performance.

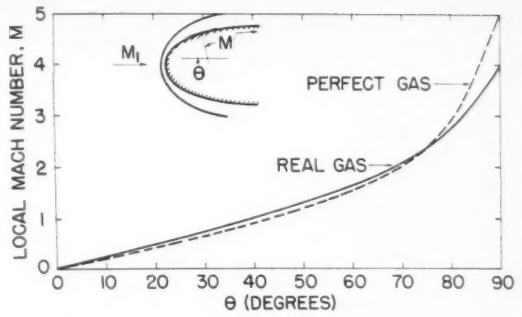


FIG. 10. Local Mach Number distribution over blunt body, real gas effects, flight Mach Number: 20.6, altitude: 150,000 ft.

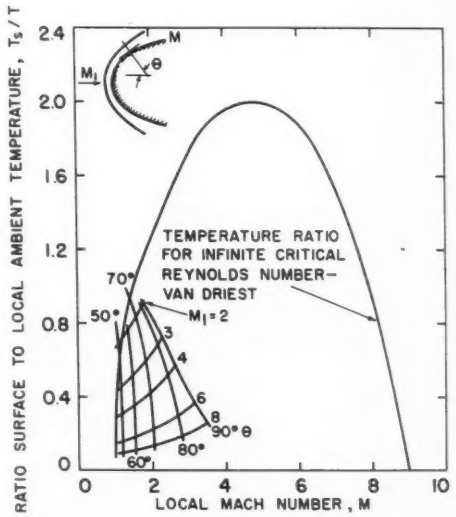


FIG. 12. Ratio of model surface to local ambient temperature, short flight in range.

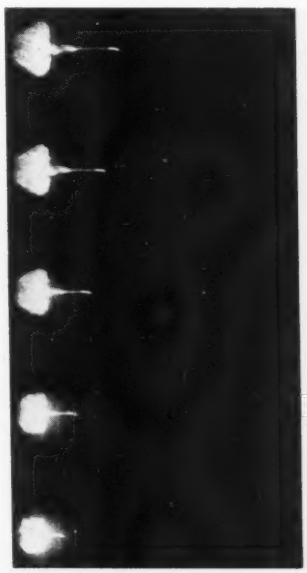


FIG. 15. 40-mm. nylon ball fired from helium gun at 11,500 ft./sec. Projectile, wake, and gun flash.

the projectile along the barrel out of the gun is converted into kinetic energy of the projectile at the muzzle end. Assuming the initial pressure, p_0, behind the projectile could be maintained, a fictitious maximum speed would be then produced: $U^2_{max} = 2p_0AL/m$, with A the bore cross section, L the length of the barrel, and m the mass of the projectile. Actually, the speed must be lower since p_0 is not constant. It decreases when the projectile moves in the barrel according to the unsteady expansion

$$p = p_0\{1 - [(\gamma - 1)/2](u/a_0)\}^{2\gamma/(\gamma - 1)}$$

with a_0 the initial sonic speed of the propellant. The relation between mass, acceleration, and force in any instant leads then to

$$\int_0^{u_x} \frac{udu}{\{1 - [(\gamma - 1)/2](u/a_0)\}^{2\gamma/(\gamma - 1)}} = \frac{p_0A}{m} \int_0^x dx$$

or the integral taken up to the end of the barrel

$$\int_0^U \frac{udu}{\{1 - [(\gamma - 1)/2](u/a_0)\}^{2\gamma/(\gamma - 1)}} = \frac{p_0AL}{m} = \frac{U^2_{max}}{2}$$

This equation shows the relation between the possible muzzle velocity U, the initial sonic speed of the propellant on the one side, and the gun parameters—e.g., length and bore area of the barrel and the initial pressure on the other side.

Fig. 13 shows this relation in a dimensionless curve, calculated by Z. I. Slawsky and A. E. Seigel of the NOL, where the speed U and the sonic speed a_0 are divided by the fictitious U_{max}. This curve can be used for any particular gun. It can be seen that the initial sonic speed $a_0 = \sqrt{\gamma(RT/M)}$ must be as large as possible to come close to U_{max}—that is, the temperature must be high and the molecular weight of the gas low. Both requirements are fulfilled with hydrogen or helium heated by adiabatic compression or combustion. Helium is preferable because hydrogen causes embrittlement of the barrel. NOL has built a 40-mm. gun with helium[5] which is heated by the combustion of a mixture of oxygen and hydrogen, which gives a propellant of the molecular weight 6 instead of approximately 28 of gun powder. The combustion temperature is about 2,700° K.

Fig. 14 shows the calculated performance of the 40-mm. gun of 400-cm. length. The two curves are obtained from the dimensionless curve in Fig. 13, taking $\gamma = 1.5$ and adding some calculated correction in the order of 10–15 per cent for "chambrage," the diameter ratio of combustion chamber and barrel. By firing 40-gm. nylon balls from the evacuated barrel, 11,500 ft./sec. has been obtained. Another half-inch gun with 200-cal. length fired already 12,600 ft. with magnesium slugs.

Fig. 15 shows the high-speed camera pictures of the 40-mm. nylon ball in 1 atmosphere. The air in its vicinity is luminescent. Shots with $^3/_{10}$-in. spheres at 11,600 ft./sec. in pure nitrogen at 1 atmosphere did not show luminescence. How to get detail information with respect to boundary-layer transition, heat transfer, and pressure from such shots will be seen in the future.

Conclusion and Outlook

This short excursion into the field of experimental hyperballistics has only scratched the surface of a few problems connected with some approaches to get more information for the design of future hypersonic vehicles. More investigations about new accelerators, ranges, and wind producers are going on at present which are very much in the beginning stage. This is true also for the instrumentation of these facilities. Small transmitters, for example, have been built at NOL which fit in 20-mm. shells which give so far only limited information on spin and base pressure. Their development has to be continued to withstand higher acceleration—that is, in the order of 50,000 to 1,000,000g. With such telemetering devices available, the results from small-scale model tests in ranges, together with the data from shock tubes, and hypersonic wind tunnels should contribute considerably and economically to the prediction of the behavior of full-scale vehicles in the future.

References

[1] Hilsenrath, J., and Beckett, C. W., *Thermodynamic Properties of Argon Free Air*, NBS 3991, July 7, 1955.

[2] Smiley, E. F., *Thermal Conductivity Measurements in Argon at High Temperatures* (to be published).

[3] Eckerman, J., *The Effect of Vibrational Relaxation on the Detachment Distance of the Head Shockwave in Front of Spheres*, Master's Thesis, Catholic University of America, June, 1955.

[4] Schwartz, R. N., and Eckerman, J., *Shock Location in Front of a Sphere as a Measure of Real Gas Effects*, Journal of Applied Physics, Vol. 22, No. 2, pp. 169–174, February, 1956.

[5] Dawson, V., Shepard, B. M., and Thurston, P. A., *Recent Results on the Capabilities of a 40-mm Hypervelocity Launcher*, First Symposium on Ballistic Missiles at The Ramo-Wooldridge Corporation, Los Angeles, June, 1956.

Now Available

Proceedings of the Third National Turbine-Powered Air Transportation Meeting

San Diego, Calif.—August 15–17, 1956

Contains papers and technical discussions presented at this meeting, complete with figures and illustrations.

Member Price, $3.50 **Nonmember Price, $6.00**

Copies may be obtained by writing to: **Publications Dept., IAS, 2 East 64th St., New York 21, N.Y.**

Passenger Air-Line Economics

Lloyd B. Aschenbeck*
Douglas Aircraft Company, Inc.

The use of market research techniques to study the factors affecting the air travel industry, with specific reference to the problem of traffic forecasting.

THE BASIS for any analysis of passenger air-line economics should be an exploration of all factors which influence the common carriage of people and things. Some of these factors are

(1) The economics of a country.
(2) The basic economy of a region within a country served by the carrier.
(3) Fare structure.
(4) Choice of efficient aircraft for the routes.
(5) The extent of competition.

This analysis will touch briefly on these factors. To bring these elements into their proper perspective, it is probably best to consider them as incremental parts of a larger market research problem. The problem selected for demonstration is that of traffic forecasting.

To begin, it is appropriate to place the transportation industry in its proper niche in the economic background of the entire country.

Fig. 1 is a picture of the American economy. It shows the elements which make up Gross National Product and how the money is spent, with the portion spent on transportation highlighted.

In addition to the economic elements, consideration must be given to such factors as marketing techniques, competition, and the spending desires of the public. Competition implies a contest; the various divisions of personal consumption expenditures are competing for a portion of the consumer dollar. Therefore, travel itself is competing with the manufacturers of washing machines, refrigerators, clothing, etc., for a share of available purchasing power. In 1954, approximately 9 cents of each National Income Dollar was spent on travel. Air travel, as one form of transportation, is also competing with rail, bus, sea, and the automobile for a larger share of this dollar.

Of the total money spent for travel by the people of the United States, we find that 87.4 per cent is spent through the use of the private automobile. Another 8.2 per cent is accumulated in daily commuter traffic, leaving only 4.4 per cent to be spent on the intercity common carrier services.

A further breakdown reveals that only 0.184 cents of each National Income Dollar is spent on air travel.

An analysis of the common carrier agencies over the last 30 years shows that there is a downward trend in the number of passenger-miles purchased per $100 of National Income or, as we have named it, "the traffic factor" (Fig. 2). This means that, as an industry, common carrier traffic is losing in the competitive race for a share of the consumer dollar.

When we examine this element, we find that the amount of air travel purchased per $100 of National Income is increasing (Fig. 3) but that the amount of surface travel purchased is decreasing (Fig. 4). In recent years air travel's share is growing at a faster rate than the rate of decrease of surface travel. Present trends indicate that air will continue to increase its percentage of total common carrier travel. As this occurs it may be possible for common carrier travel, as an industry, to regain its competitive position for the consumer dollar.

Inasmuch as travel may be tied to the economy of the United States as represented by National Income, it is obvious that, to make a travel projection, a forecast of National Income is needed. It is not the intent of this report to discuss methods of forecasting National Income. These forecasts are intended to reflect changing conditions of population increases, labor rates, hours worked per week, and other more finite values which are included in the measurement of an economy. A National Income forecast was developed by the Joint Committee on Economic Report of the Congress (Fig.

Presented at the Economics Session, National Summer Meeting, IAS, Los Angeles, June 18–21, 1956.

* Supervisor—Market Research, Santa Monica Division.

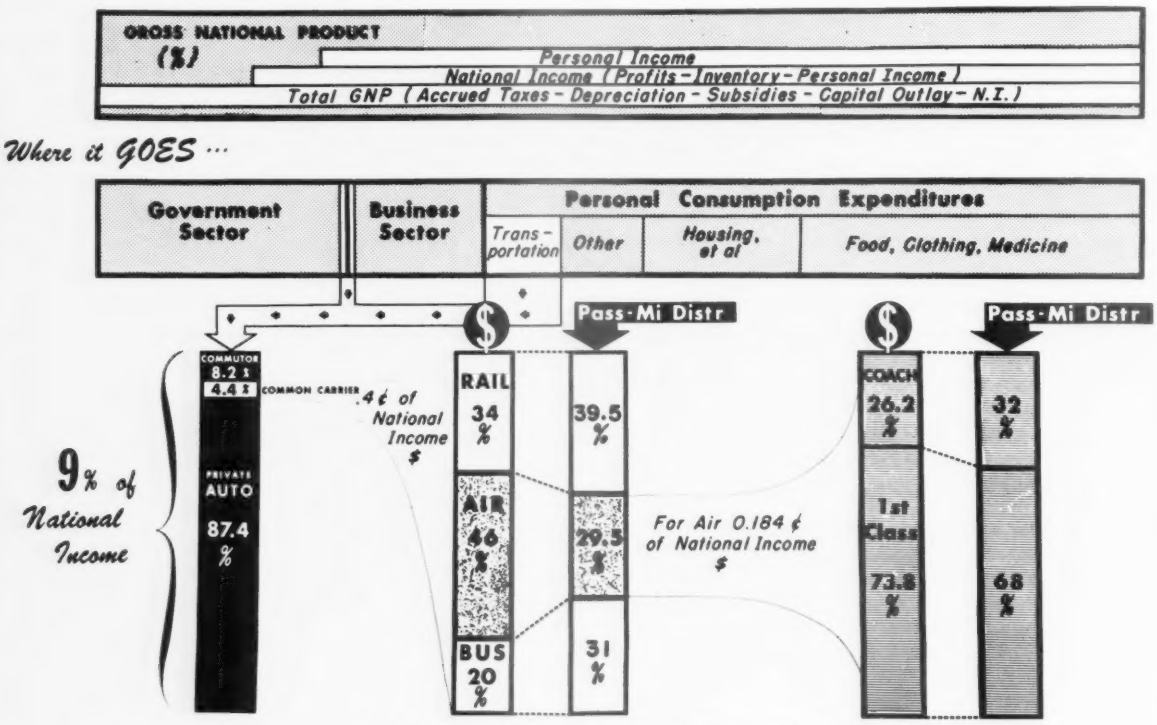


FIG. 1. Air travel and the American economy, 1954.

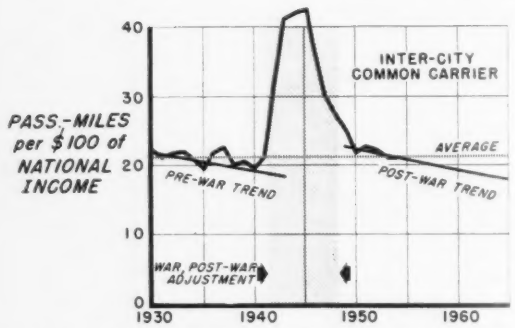


FIG. 2. United States passenger-miles per $100 of National Income.

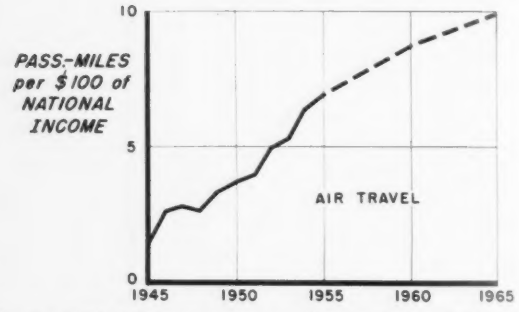


Fig. 3. United States passenger-miles per $100 of National Income.

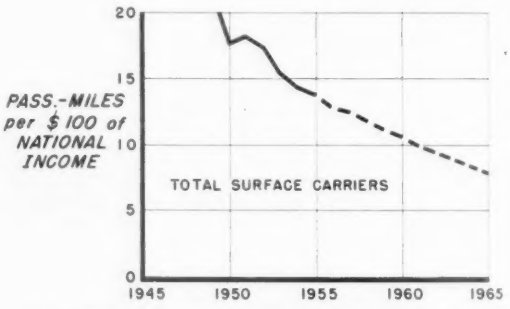


FIG. 4. United States passenger-miles per $100 of National Income.

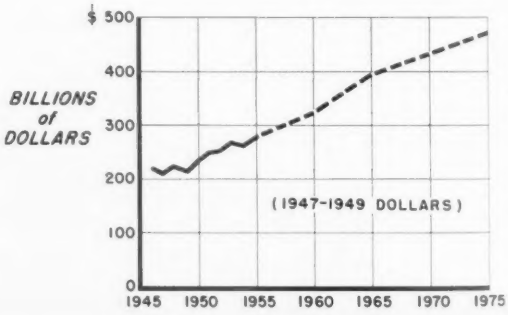


FIG. 5. National Income.

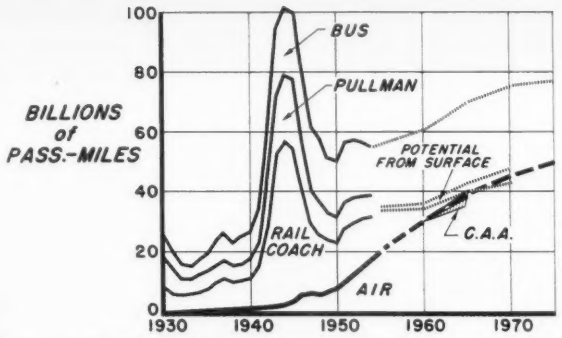


FIG. 6. United States passenger transportation; domestic common carrier, air and surface.

5). Applying the travel factor to this forecast, we can establish the basic trend line for probable common carrier traffic development in the United States.

Having established the travel trends for surface and air, it is possible to forecast the relative values for each mode of transportation. On this basis, we see in Fig. 6 that in 1960 air will account for nearly 50 per cent of total United States common carrier travel and 55 per cent by 1965. Looking ahead to the 1970–1975 era, it is possible to foresee that two thirds of all common carrier travel in the United States will be by air. To achieve this, air lines have asked for rate reductions through the use of coach flights and other types of reduced fare plans. These lower rates, the tremendous savings by air, as well as other factors which may be lumped together under the title of technological advancements have given air travel a tremendous appeal to the traveling public. As this trend to lower air fares continues, coupled with the accelerated acceptance and desirability of air travel, air transportation will more quickly absorb that portion of the surface traffic which falls in the medium-to-long range trip-segment length.

Rail and bus travel are declining as a result of penetration by air and diversion to private automobile. The forecasts of this decline are shown in Fig. 7. A breakdown of surface travel revealed that a substantial portion of present traffic could be absorbed by air. This was developed by an analysis of rates and trip-segment lengths traveled. The total amount of this penetration is shown in Fig. 6 as an additive to the normal air traffic forecast. This penetration is gradually occurring, and, in some parts of the country, surface transportation presently exists as a supplemental service.

The logic behind this assumption lies in the fact that, because of improved air services and reduced rates, the air lines are offering more "travel value" per dollar of cost than any other form of transportation. This philosophy of more-for-your-money is the basic appeal which combined with proper distribution means success in the marketing field.

The speed with which this program is developed will determine the volume of traffic carried. The farsighted air lines have made sufficient aircraft purchases today so that by 1960 they will have the equipment available to handle most of the market potentials.

Supply is normally dependent on demand. Therefore, to express the forecast demand for passenger-miles in terms of supply, it is necessary to arrive at a seat-mile forecast. The seat-mile forecast is shown in Fig. 8. This was developed by applying a passenger load factor to the passenger-mile forecast. The 1951–1955 average United States domestic load factor was 64.1 per cent. It is felt that a 64 per cent load factor is too high for a sustained average in that it restricts scheduling flexibility. However, we have used it to establish the lower limit of our forecast band. The upper limit is based on an average load factor of 55 per cent. This year-round load factor not only will assure profitable operation but will achieve the requirements of adequate scheduling and ability to handle peak loads. Present reciprocating aircraft have an average breakeven load factor, for total costs, slightly greater than 50 per cent. It should be remembered, however, that by 1965 nearly two thirds of all seat-miles will be produced by turbine-powered aircraft which have average breakeven load factors less than 50 per cent.

Realistic seat-mile productivity of the various types of aircraft operating in domestic scheduled service was constructed on the basis of official Air Transport Association data. The analysis also provided the proportion of air-line equipment operated by the domestic trunk lines on international schedules. The proportion, utilization, and seating capacity have been used as the basis for estimating the productivity of the equipment operating domestically in 1960 and 1965. The 1955 bar

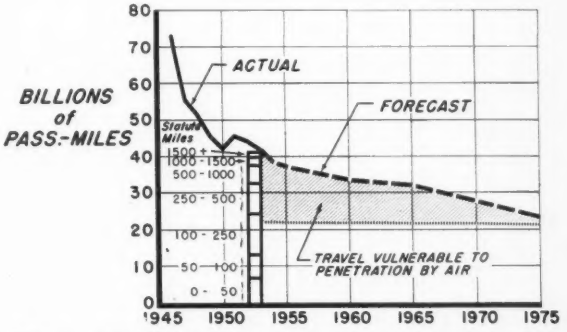


FIG. 7. Total United States common carrier passenger-miles.

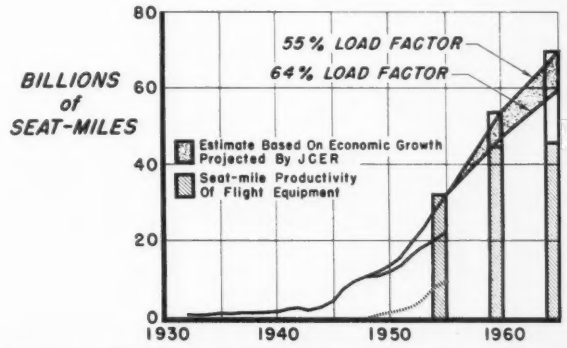


FIG. 8. United States domestic air lines, seat-miles and equipment.

in Fig. 8 shows seat-mile productivity of flight equipment operating as of December 31, 1955. In developing the seat-mile productivity of equipment operating in 1960 and 1965, the following assumptions were made:

(1) Equipment now on order will be delivered and operated by year end 1960.

(2) Optional orders for jet transports will be delivered and operated prior to 1965.

(3) Present reciprocating-engine aircraft will be gradually retired from the major trunk lines and will find a market in other types of service.

(4) Aircraft of the DC-6 type and DC-6B's will all be operating as coaches by 1960.

Based on these assumptions, the bars for 1960 and 1965 indicate the productivity of aircraft operating during those periods. Based on the forecast band, the United States demand for scheduled domestic seat-miles will exceed supply in 1965 by 14.5 to 24.5 billion seat-miles.

This method may be used to get a quantitative feel for the future requirements of commercial aircraft. In addition it establishes a control curve within which the forecast of regional traffic must operate. Region, as used in this report, may be applied either to a specific geographical area in a country, or it may be applied to the area or areas served by a given air line. It is well known that here in the United States large shifts in population have taken place. We have witnessed the migration of people from the Eastern seaboard of our country to the Southwest and Pacific areas. The Bureau of the Census states that in the last 20 years the theoretical population center in the United States has moved from a point in Indiana to a point in Illinois. This change, as well as the increase in population and the new industries which are springing up all over our country, have a tremendous effect on the changing economics of a given marketing area.

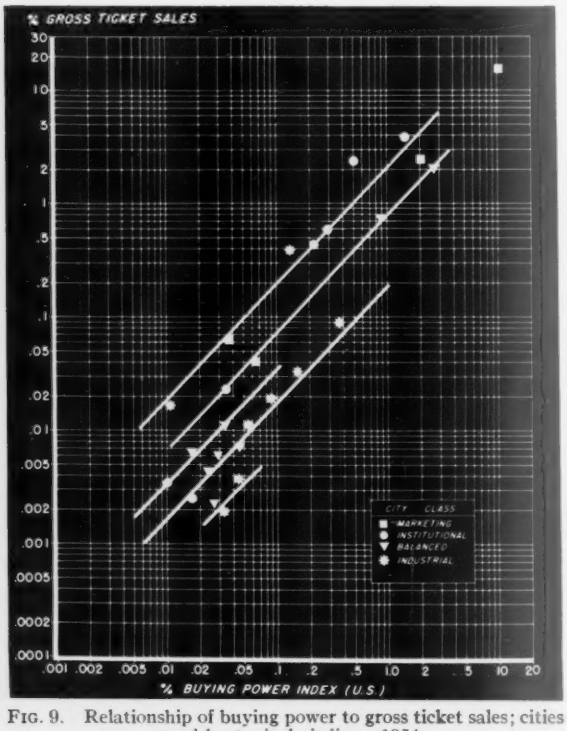


FIG. 9. Relationship of buying power to gross ticket sales; cities served by typical air lines, 1954.

The Civil Aeronautics Administration has grouped the cities served by the air lines into four classes: *marketing*, *institutional*, *balanced*, and *industrial*. By use of several economic indicators, a symptomatic index of the buying potential of a city can be assigned. This index shows a close correlation to the amount of air passenger-miles emanating from the city (Fig. 9). The elements which make up this index are population of the area, retail sales, and disposable income.

The sensitivity of air travel to disposable income has been clearly presented by the *Survey of Current Business*, September, 1955. Expenditures for air travel, more than any other personal spending, show the greatest sensitivity to change with each 1 per cent change of disposable income. During the postwar period, 1947–1954, the *Survey of Current Business* states that personal expenditures for air travel changed +2.7 per cent for each 1 per cent change in disposable income. Expenditures for railway travel (excluding commutation during the same period) changed −0.6 per cent for each 1 per cent change in disposable income. Since this demonstrates a particular sensitivity to one of the major economic indicators, it appears that a symptomatic index should contain disposable income to reflect the ability of a regional economy to generate travel by air.

It may appear that cities of equal buying power should generate equal amounts of air travel. However, the ability of a city to enplane passengers is dependent in great measure upon the major economic character of that city. For instance, a city which is classified according to the CAA type as *industrial* will not, as a rule, generate as many passenger-miles as a city classified as *marketing* or *institutional*, even if the former city has an equal buying power for consumer goods as measured by the Buying Power Index.

The growth rate of this index for a given city or a group of cities in a region provides the indication of the economic development of the area to be studied. Because of the close correlation between the basic index and air traffic, it may also be assumed that air passenger-miles will grow at a rate commensurate with the growth of the components of the index. Therefore by relating the growth rate of a region to the economic and air traffic growth rates of the nation, an air passenger traffic forecast can be made for a specific region. This method permits us to integrate traffic development for all the given areas of a country within the basic national air travel forecast control curve.

In order to convert passenger-miles to seat-mile requirements, the passenger-mile forecast is divided by a load factor requirement which results from an air line having sufficient equipment on hand to handle peak traffic loads, as well as to operate economically during off-season periods.

The last phase of this analysis deals with the equip-

ment needs of the specific air line. This is the translation of the forecast passenger-mile or seat-mile demand into the proper type of equipment.

We have mentioned technological advance as one of the contributing factors to increased travel by air. This advance includes development of airport terminal facilities, ground-handling methods, passenger loading and handling techniques, simplified ticketing and reservation, scientific scheduling, production-line maintenance of flight equipment, and many other breakdowns of these items. In the past, these developments usually followed the creation of advanced types of flight equipment. The burden of economic efficiency has always been placed and probably should remain to a great extent within the aircraft itself.

In developing new equipment, the Douglas Company has followed the basic concept that each new airplane must offer features which will help advance the aviation industry. In looking at the need for future aircraft, therefore, the Douglas Company considered, in general, the following elements: service, dependability, speed, and operating costs. The familiar airplane operating cost curve tells us that, as the range of aircraft increases, its economy improves within certain limits. Therefore, the aircraft manufacturer pays close attention to reducing the operating costs in the short-range portion of the curve. Much effort, for example, was put into DC-8 development along these lines, with the result that with the versatile DC-8 the lowest operating costs have been achieved.

In considering the type of aircraft to be operated, some of the things an air line examines are the following items: its route structure, scheduling needs, type of service (First Class, Coach), the performance economics of the airplanes available, and competition. The air-line route structures which have been developed during the past 25 years have established flight segment lengths which may be classified into two groups—short-to-medium range and long range. There is no correlation between traffic volume carried on a given route and segment length. We find high traffic density on all elements of the route spectrum. On these high traffic density routes, it has been customary to use large equipment to handle the traffic volume efficiently. Large equipment is normally associated with long-range capability. This paradox creates problems for the airplane designer because he must design into his product a flexibility of operation to do the job required. Simultaneously with the high traffic density, we find a great number of flight segments of a relatively low

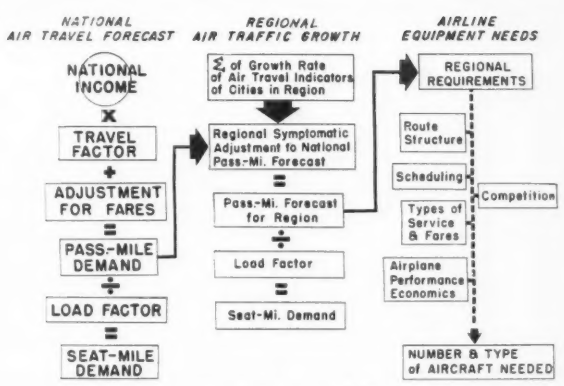


FIG. 10. Summary, passenger air-line economics.

traffic density. Obviously this type of operation demands flight equipment with a high order of economy. Once again the aircraft manufacturer must produce an airplane to do a job which will be comparable in comfort and speed with the large aircraft used on the high traffic density routes. By working with the air lines, this type of equipment can be designed and built. Having the best equipment available to do the most economical job, the air line turns to the scheduling and type of service requirements in its region of operation. Passenger travel habits with regard to departure and arrival times are faily well established, and the air line pays close attention to the desires of its customers. Reduced fare services require the consideration of available equipment, the latent travel potential of the area, the class of service offered by competition, and the many other special problems which may apply locally. When all of these elements are considered, weighted properly, and combined with the basic seat-mile requirement, the purchase of suitable airplanes may be made.

The flow chart on Fig. 10 is a summary of the preceding discussion. It shows the relationship of National Air Passenger-Miles to National Income. The dynamics of regional economy are used to determine the portion of national air travel which a region can produce. Finally, the chart briefly covers the considerations inherent with the acquisition and use of airplanes by the operator. These highlights serve to indicate how well commercial aviation has integrated itself into the economy of our country.

The use of these market research techniques will bring into focus the future potential that exists in air travel.

M. J. Zucrow*
Purdue University

Engine weight, design point performance, combustion problems, and the need for converging-diverging exhaust nozzles are some of the considerations examined in this paper.

The Problems of the Turbojet Engine as a Propulsion Engine for Supersonic Flight

Symbols

c_0 = $\sqrt{2g\,J\,c_p\,t_0}$ = maximum isentropic speed
c_p = specific heat at constant pressure, B.t.u./lb.-R.
c_v = specific heat at constant volume, B.t.u./lb.-R.
F = thrust, lb.
g = acceleration due to gravity, ft./sec.^{2}
Δh_n = enthalpy drop in exhaust nozzle, B.t.u./lb.
k = c_p/c_v = specific heat ratio
M_0 = flight Mach Number
p_0 = static temperature of atmospheric air, psia
P_0 = total pressure of atmospheric air
P_2 = total pressure of air entering compressor
P_3 = total pressure of air leaving compressor
Q_i = heat added in combustors, B.t.u./lb.
t_0 = ambient static temperature, °R.
T_2 = total temperature of air entering the air compressor, °R.
T_3 = total temperature of air leaving compressor, °R.
T_4 = total temperature of gas entering turbine, °R.
T_5 = total temperature of gas leaving turbine, °R.
T_6 = total temperature of gas entering exhaust nozzle, °R.
V_0 = flight speed, ft./sec.
V_j = effective jet speed, ft./sec.
$\dot{W}_a$ = weight rate of air consumption, lb./sec.
$\dot{W}_f$ = weight rate of fuel consumption, lb./hour
α = T_4/t_0 = cycle temperature, ratio
α_d = T_2/t_0 = diffuser temperature, ratio
Θ_c = $(P_3/P_2)^{(k-1)/k}$ = compressor pressure ratio parameter
ν = V_0/V_j = speed ratio
η_B = combustion efficiency
η_c = isentropic efficiency of air compressor
η_d = isentropic efficiency of diffusion system
η_t = isentropic efficiency of turbine
λ = $Fg/\dot{W}_a\,c_0$ = dimensionless thrust parameter

Introduction

The object of this paper is to discuss some of the problems which must be surmounted in developing turbojet engines for propelling aircraft at supersonic speeds. Although the discussions are confined to the characteristics of the turbojet engine, it is recognized that the accomplishment of supersonic flight depends not only upon the characteristics of the propulsion engine but also upon those of the aircraft it is to propel.

A review of the maximum speeds attained by different classes of aircraft over the 50-year period 1902–1953 shows that, since the introduction of the turbojet engine after World War II, the slope of the curve of flight speed as a function of years has become much steeper.[1] Today there are operational military aircraft flying in the transonic range, and we are about to embark upon an era of truly supersonic flight. Although the turbojet engine is not the propulsion engine for achieving the ultimate in flight speeds, it appears that piloted supersonic aircraft for several years to come will be propelled by some form of turbojet engine.[2] Although the emphasis in the design of an engine must recognize the mission of the aircraft to be propelled, it can be stated quite categorically that as flight speeds are increased the fraction of the take-off weight of an aircraft which must be devoted to the engine plus its fuel will increase. As a result, for flight Mach Numbers exceeding approximately 2, the characteristics of the propulsion engine will tend to dominate the basic flight performance of the aircraft.[3]

Basic Problems of the Turbojet Engine

Early in the development of the turbojet engine it was recognized that, because it was a continuous-flow, air-consuming engine, its performance would be affected by the flight speed and the operating altitude, and its success involved solving certain inherent problems. Although those earlier investigations were concerned mainly with propelling aircraft at high subsonic speeds, we find that the same problems will be present to an aggravated degree in connection with the development of turbojet engines for propulsion at supersonic speeds. In addition, several new problems arising from the high stagnation temperatures associated with supersonic flight must also be overcome. The problems due

Presented at the IAS Indianapolis Section Meeting, March 12, 1956.

* Professor of Gas Turbines and Jet Propulsion.

to high stagnation temperatures will always be present to plague the engine designer as the demands for higher flight speeds must be met. If he solves them for one flight Mach Number, then he must solve them again for the next higher flight Mach Number. The engine designer finds that, after "crashing the so-called sonic barrier," he has become "bogged down in an infinite thermal morass" from which he can extricate himself only by abandoning air-consuming engines.

Essential Features of the Turbojet Engine

The turbojet engine for subsonic flight propulsion comprises the following essential elements:

(1) A subsonic diffuser.

(2) An air compressor (radial or axial flow).

(3) A combustion system.

(4) A turbine for driving the air compressor.

(5) A tailpipe which may or may not be equipped with an afterburner.

(6) A fixed or variable area exhaust nozzle.

As illustrated in Fig. 1, the following modifications are required to make the engine applicable to supersonic flight propulsion. Thus

(1) A supersonic diffuser must precede the subsonic diffuser.

(2) The inlet area of the engine should be variable.

(3) The air compressor must be of the axial-flow type.

(4) The tailpipe must be equipped with an afterburner.

(5) The exhaust nozzle area must be variable.

The assembly comprising the diffusion system (supersonic plus subsonic diffusers), the air compressor, the combustion system, and the turbine constitutes a *gas generator* for supplying high-temperature gases at a pressure above that of the surrounding atmosphere to an exhaust nozzle—the latter being the propulsive element of the engine.

The thermodynamic cycle illustrated in Fig. 1 assumes no losses in pressure between stations 5 and 6 so that the reheating in an afterburning engine takes place at substantially constant pressure. In a nonafterburning engine, the temperature of the gas at the inlet to the exhaust nozzle (station 6) will range from 900°F. to 1,300°F. depending upon the design of the engine, while in an afterburning engine, the *nozzle inlet temperature* T_6 will be of the order of 3,500°F.

For the successful operation of a gas-turbine type of engine, such as a turbojet engine, its component machines—the air compressors and turbines—must have high isentropic efficiencies. Otherwise, the required *turbine inlet temperature* T_4 becomes too high for the metals available for making turbine blades.[4] Moreover, the air compressor must be reliable, light in weight, compact, and capable of operating satisfactorily over a wide range of conditions and have a large air induction capacity and a small frontal area. Similar demands are placed upon the turbine, but in addition it is desirable that it be capable of operating with the highest possible inlet gas temperature. With regard to the combustion system, it must be light in weight, have a small frontal area and total volume, and operate with a small decrease in total pressure, the highest possible heat release, and high combustion efficiency. In general, the aforementioned requirements are applicable to turbojet engines for propelling aircraft at either subsonic or supersonic flight.

Performance Parameters for the Turbojet Engine

The immediate discussion will be concerned in the main with the characteristics of the nonafterburning turbojet engine at its design point, and for that purpose the judgments regarding its suitability for a specific propulsion problem can be studied in terms of the following three parameters:

(1) The specific engine weight (W_e/F_0).

(2) The thrust per unit of frontal area of the engine (F/A_F).

(3) The thrust specific fuel consumption (TSFC = W_f/F).

Specific Engine Weight

The specific weight of a turbojet engine is defined as its weight W_e divided by the static thrust at design r.p.m. with the afterburner inoperative. Since the ratio W_e/F_0 is a measure of the weight of *fuel plus pay load* that can be carried in the airplane, it is desirable that W_e/F_0 be small. The principal factors influencing the specific engine weight are the pressure ratio of the engine, the air induction capacity of the engine, the frontal area of the engine, the nozzle inlet temperature T_6, and the materials for constructing the engine and the allowable stresses.

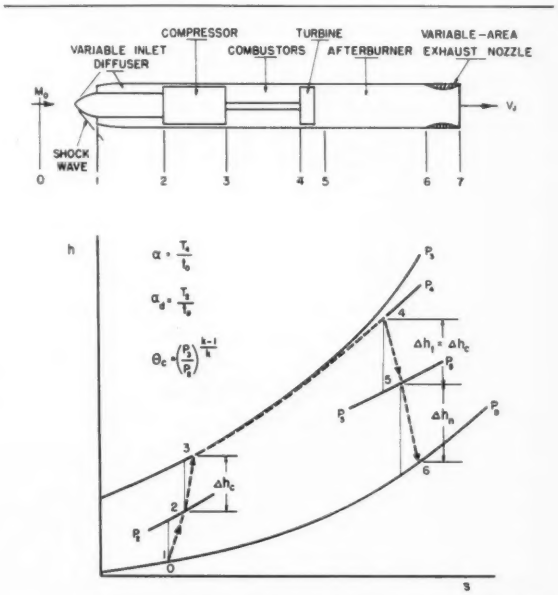


Fig. 1. Thermodynamic cycle for the turbojet engine on the h-s plane.

Thrust per Unit of Frontal Area

The thrust per unit of frontal area (F/A_F) measures the thrust available for overcoming the combined drags of the air frame and the engine. As the desired flight speed is increased, the more essential it becomes that the F/A_F have a large value. It is obvious that there are only two basic approaches to increasing the current values of thrust per unit of frontal area: (a) increasing the air induction capacity of the engine, and (b) increasing the jet velocity (or both).

Thrust Specific Fuel Consumption

Both the thrust specific fuel consumption TSFC and the specific engine weight (W_e/F_0) affect the range obtainable from a given airplane. Obviously, for a given fuel load, a low value of TSFC is conducive to securing a long range. Because the specific engine weight (W_e/F_0) also exercises an influence, the estimation of the range of an aircraft must consider both of the aforementioned performance parameters, assuming no change in the fuel.

General Considerations Pertinent to Engine Weight

It is of interest to discuss in a brief manner the parameters influencing the weight of a turbojet engine. In general, there are two approaches for reducing the weight of a turbojet engine:

(1) Decreasing the weights of the engine components by better mechanical design.

(2) Increasing the thrust output from the same weight of engine.

Undoubtedly some reductions in engine weight can be achieved by changes in metallurgy and improved mechanical design, but the greatest reductions in specific weight will come from those improvements which contribute to increasing the *air specific impulse* (or *specific thrust*) and the air induction rate per unit of frontal area.

*Air Specific Impulse**

The air specific impulse depends primarily upon the magnitude of the jet thrust which in turn depends upon the nozzle inlet temperature T_6 and the nozzle pressure ratio P_6/p_7. If the nozzle inlet temperature can be increased, then a given thrust will be developed with a smaller mass rate of airflow thus making it possible to reduce the frontal area of the engine. The nozzle inlet temperature can, of course, be increased by afterburning; estimates indicate that the specific weight of an afterburning engine will be approximately 20 per cent less than that for its nonafterburning counterpart. The smaller specific weight is obtained, however, at the expense of a large increase in fuel consumption so that the net advantage of the afterburning engine in a given case can be determined only from an analysis which compares the performances and ranges of the aircraft with the afterburning and nonafterburning engines.

The nozzle inlet temperature could also be increased if it were possible to cool the turbine blades so that higher than current turbine inlet temperatures were permissible. The required turbine pressure ratio would thereby be reduced, and the nozzle pressure ratio would be increased. Not only would the thrust output be increased but in addition the size of the turbine for a given thrust would be reduced. If an increase in turbine inlet temperature is unfeasible and a larger jet thrust must be obtained from the engine, then afterburning must be employed.

It may be of interest to consider briefly the principal factors influencing the weights of the compressor and the turbine, the two heaviest components of the engine.

Factors Affecting Compressor Weight

The weight of an axial-flow compressor is governed by its diameter, its length, and the materials for constructing it. The diameter will depend upon the engine r.p.m., the overall pressure ratio, and the airflow rate per unit of frontal area. Its length will be governed by the length of a stage and the number of stages required to achieve the design pressure ratio. An increase in the airflow rate per unit of frontal area requires either increasing the area of the flow annulus of the first stage, which signifies a small hub-to-tip ratio, or increasing the axial velocity of the air entering the compressor annulus, or both.

In general, the weight of an axial-flow air compressor decreases as its rotational speed is increased. A speed is finally reached, however, where the centrifugal loads become so large that, because of stress considerations, further increases in rotational speed are accompanied by an increase in the weight of the compressor. Since the stresses acting on the components of a compressor increase with the absolute gas pressure, high pressure ratio machines must be equipped with heavier blades, drums, and casings. At high flight speeds, the temperature of the air T_2 at the entrance to the first stage of the compressor influences the weight of the air compressor by virtue of its effect upon the allowable stresses for the materials employed in constructing the compressor; for all materials the allowable stress decreases with temperature. The material selection and stress problems are, of course, most severe in the last stages of the machine where the pressure and temperature levels are the highest.

Factors Affecting Turbine Weight

The weight of the turbine, like that of the air compressor, depends upon its diameter, the number of stages, and the turbine inlet temperature; the latter dictates the allowable stresses in the turbine materials. The number of stages depends upon the rotational speed, the weight rate of gas flow, and the pressure and temperature at the entrance to the first stage. In-

* Air specific impulse or specific thrust = thrust/air weight flow rate.

creasing the compressor pressure ratio for the same engine speed and turbine inlet temperature requires increasing the turbine diameter so that the peripheral speed will be large enough for developing the increased turbine work required. Raising the turbine inlet temperature increases the available enthalpy which permits the turbine to develop the required amount of work at a lower peripheral speed. Increasing the engine r.p.m. decreases the required turbine diameter and also may reduce the number of stages. As in the case of the air compressor, an engine speed is finally reached where the stresses become excessive.[5]

Effect of Flight Speed on Design Point Performance

The design point performance of the turbojet engine in flight will be discussed in terms of its thrust performance and its overall thermal efficiency. Before discussing those parameters, however, the influence of the flight Mach Number on the performance of the diffusion system and the air compressor will be considered.

Diffuser Performance

The air induction capacity of the supersonic turbojet engine and also its cycle efficiency depend to an important extent upon the performance of the diffusion system—that is, of both the supersonic and subsonic diffusers.

For the lower supersonic speeds, up to approximately $M_0 = 1.5$, the diverging subsonic diffuser with a normal shock at the entrance may give satisfactory pressure recoveries. For the higher flight speeds, however, the subsonic diffuser must be preceded by some form of supersonic diffuser, such as the spike-type illustrated in Fig. 1, for reducing the free-stream Mach Number of the air to a value close to the sonic value before it enters the subsonic diffuser. From the experiences with supersonic ram-jet engines, it is evident that, if a turbojet engine is to operate over a wide range of flight Mach Numbers from subsonic up to $M_0 = 3$, for example, then a fixed geometry diffusion system will not be satisfactory.[6] Moreover, the adverse operating characteristics of the fixed geometry diffuser become more serious as the supersonic flight Mach Number is increased. Consequently, for best performance, the turbojet engine for supersonic flight propulsion should be equipped with a diffusion system which permits adjusting the inlet area and shock wave pattern so that the airflow requirements can be correctly matched at all flight speeds.

Effect of Mach Number on Compressor Outlet

As the supersonic flight speed is increased, the stagnation temperature of the air increases rapidly [see Eq. (1)]. The engine, as well as the air frame, must be constructed to withstand certain static and dynamic pressures, and, in the interest of having the most favorable stress conditions for the engine components, supersonic flights must be conducted at altitudes above 35,000 ft. where the air densities are small and the static temperature of the atmosphere (−67°F.) is the lowest available.[7]

The total temperature of the air entering the first stage of the air compressor, denoted by T_2, is given by

$$T_2 = t_0\,\alpha_d = t_0\,\{1 + [(k-1)/2]\,M_0^2\} = t_0\,(1 + 0.2\,M_0^2) \quad (1)$$

The temperature of the air at the outlet of the compressor may be calculated from the compressor temperature rise $(T_3 - T_2)$, its pressure ratio P_3/P_2, and its isentropic efficiency η_c. Thus

$$T_3 = t_0\,(1 + 0.2\,M_0^2)\,\{[(\Theta_c - 1)/\eta_c] + 1\} \quad (2)$$

Eq. (2) shows that the compressor outlet temperature T_3 can attain large values at high supersonic flight speeds. For example, if $M_0 = 3.0$, then at altitudes above 35,000 ft. the values of T_3 will be approximately 1,000°, 1,100°, and 1,200°F. for compressor pressure ratios of 6, 9, and 12, respectively. Consequently, as demands for supersonic flight are increased, the blades of the compressor will be subjected to higher and higher temperatures so that the problems of material selection, stress, and weight, referred to earlier, will become increasingly difficult to solve. The problems associated with achieving simultaneously larger air induction capacity, smaller hub-to-tip ratios, satisfactory strength, high isentropic efficiency, and low compressor weight are fraught with many difficulties. Considerable research effort will be required to determine how the optimum compromise can be achieved.

Effect of Flight Speed on Specific Thrust

The thrust performance of a turbojet engine can be expressed in terms of a nondimensional thrust parameter λ, where

$$\lambda = F_g/\dot{W}_a\,c_0 = (1 - \nu)\,\sqrt{\Delta h_n/c_p\,t_0} \quad (3)$$

Fig. 2 presents the thrust parameter λ as a function of the compressor pressure ratio for a nonafterburning engine. The curves are for a constant cycle temperature of $\alpha = T_4/t_0 = 5.0$, and the calculations assumed the conditions presented in the Figure.

It is seen that for a cycle temperature of $\alpha = 5$, increasing the flight Mach Number for any compressor pressure ratio decreases the maximum value of λ. The curves show that for the nonafterburning engine the compressor pressure ratio P_3/P_2 giving the maximum value for λ decreases rapidly with the flight Mach Number, and for a compressor pressure ratio exceeding 10 to 1 the value of λ is zero when $M_0 = 2.4$.

Dimensionless Heat Addition Parameter

The heat which can be supplied to a nonafterburning turbojet engine expressed in the dimensionless form $Q_i\,\eta_B/c_p\,t_0$ is given by

$$Q_i\,\eta_B/c_p\,t_0 = (1/\eta_c)\alpha_d[(\alpha/\alpha_d)\,\eta_c - \eta_c - \Theta_c + 1] \quad (4)$$

Since the diffuser temperature ratio Θ_d is a function

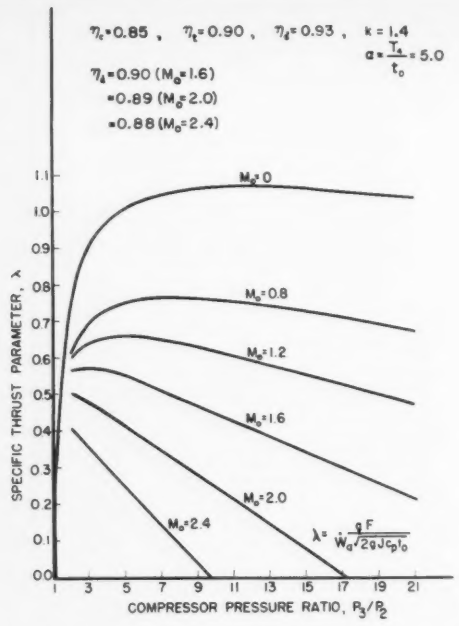


FIG. 2. Nondimensional specific thrust parameter as a function of compressor pressure ratio.

of M_0^2 [see Eq. (1)], the dimensionless heat addition parameter at altitudes above 35,000 ft. depends primarily upon the flight Mach Number, the compressor pressure ratio, the allowable turbine inlet temperature, and the isentropic efficiency of the air compressor.

If the turbine inlet temperature T_4 must be limited, which will be the case unless the turbine blades and disc can be cooled, the allowable values for T_4 will limit the quantity of the fuel that can be burned in the combustion system. Since the compressor discharge temperature T_3 increases with the flight Mach Number M_0, the amount of fuel which can be burned upstream to the turbine will decrease with increasing values of M_0. The temperature rise in the combustor is a measure of the energy available for driving the compressor and for producing the jet velocity; the latter, of course, determines the thrust output.

Fig. 3, taken from reference 8, presents the amount of fuel which can be burned per pound of air inducted by the engine as a function of the flight Mach Number. One curve is for a maximum turbine inlet temperature of 1,600°F. and the other for 1,800°F. The curves apply to an engine operating at altitudes above 35,000 ft. (where $t_0 = -67°$F.); the static sea-level pressure ratio of the air compressor is assumed to be 12 to 1. It is seen that, for the nonafterburning turbojet engine, for supersonic flight to have the same fuel-burning capacity as its counterpart for a subsonic flight, it must be capable of operating with higher turbine inlet temperatures than are currently possible.

Overall Efficiency at Design Point

It is of interest to determine the manner in which the overall efficiency of the nonafterburning turbojet engine is influenced by changes in flight Mach Number, compressor pressure ratio, and cycle temperature. Fig. 4 presents the overall efficiency η_o as a function of the compressor pressure ratio with the flight Mach Number as a parameter, for the case where the cycle temperature is $\alpha = T_4/t_0 = 5.0$. The curves show that, as the supersonic flight Mach Number is increased, the design point pressure ratio for the air compressor that gives the maximum overall efficiency decreases. For example, at a flight Mach Number of 1.6, the optimum compressor pressure ratio is approximately 12 to 1, and it decreases to 3 to 1 approximately when the flight Mach Number is raised to 2.4.

Fig. 5 presents the efficiency η_0 as a function of the cycle temperature ratio $\alpha = T_4/t_o$ for several values of the flight Mach Number. The broken-line curves apply to the case where the compressor pressure ratio is 4 to 1 and the full-line curves to a pressure ratio of 12 to 1. It is seen that, at all flight Mach Numbers, lower values of cycle temperature ratio are required to achieve good overall efficiencies if the compressor pressure ratio is low.

The results obtained from analyzing the performance characteristics of the turbojet engine cycle at the design point show that for a given temperature ratio T_4/T_2 the best performance of the engine is obtained when the pressure ratio P_5/P_2, corresponding to a given compressor pressure ratio P_3/P_2, is large. As demonstrated in the Figures, when the turbine inlet temperature T_4 is limited, then the optimum value of P_3/P_2 decreases with increasing values of T_2, the latter increasing with flight Mach Number. At some flight Mach Number the optimum value of P_3/P_2 will be unity, indicating that for that flight Mach Number neither a compressor nor a turbine is needed but only a diffuser system, combustor, and exhaust nozzle—that is, a ram-jet engine. When the optimum compressor pressure ratio P_3/P_2 is unity, the performance of a ram-jet engine operating with the same value of T_4 is superior to that of the turbojet engine. The preceding discussions of the design point characteristics of the turbojet engine demonstrate that, if there is a limit to the

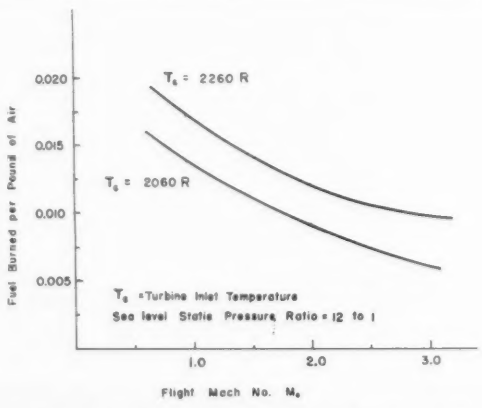

T_4 = 2260 R
T_4 = 2060 R
T_4 =Turbine Inlet Temperature
Sea level Static Pressure Ratio = 12 to 1
Fuel Burned per Pound of Air
Flight Mach No. M_o

Fig. 3. Fuel burned per pound of air as a function of the flight Mach Number for two different turbine inlet temperatures.

permissible turbine inlet temperature, then there is likewise a limit to the flight speed at which the turbojet engine can be applied effectively.

Effect of Flight Speed on Compressor Performance

The decrease in the specific thrust with increasing supersonic flight speed arises not only from the limitation imposed on the turbine inlet temperature but also from the reduced mass flow rate inducted by the engine.

Fig. 6 presents a typical performance map for a compressor. On the map the operating line for a constant value of T_6 has been drawn. If the physical speed of the engine N (r.p.m.) is held constant, then as the flight speed is increased from static sea level to $M_0 \approx 3$, for example, the operating point moves downward and to the left, from point A to point B, as illustrated in Fig. 6. The corrected engine speed $N/\sqrt{\theta_2}$ decreases because $\theta_2 = T_2/519$ increases with M_0. If the value of $N/\sqrt{\theta_2}$ at static sea level (the design point) is taken as 100 per cent, it will decrease to approximately 70 per cent when M_0 is approximately 3. At the latter operating point, the pressure ratio P_3/P_2 and the corrected airflow $\dot{W}_a\sqrt{\theta_2}/\delta_2$ have both decreased from the design point values; in general, the per cent decrease in $\dot{W}_a\sqrt{\theta_2}/\delta_2$ is larger than the corresponding per cent decrease in $N/\sqrt{\theta_2}$. It is seen, therefore, that there is a tendency for the turbojet engine to operate at the low cycle pressure ratios required at supersonic flight speeds. Unfortunately, because of the decreased weight flow and low compressor efficiency at the higher flight speeds, the thrust decreases, and the acceleration characteristics of the engine are apt to become poor.

The "off-design point" operation of a turbojet engine introduces certain problems because of the influence of the operating range upon the performance of the air compressor. Because the operating range is increased by raising the flight speed, the problems of off-design operation are aggravated as M_0 is increased. When the engine is operating at its design point, all of the stages of the axial-flow air compressor (and also those of the turbine) are presumably matched correctly. The performance characteristics of a stage of an axial-flow compressor can be presented by curves of η_c and $\Delta p/u^2$ as functions of the velocity ratio u/c_m; the latter ratio is basically a measure of the angle of attack made by the incident air and the rotor blades. At the design point, the value of η_c is close to its peak value. For a given value of u/c_m, the pressure rise for the stage increases practically with u^2. Referring to Fig. 7, it is seen that, if the engine speed is constant, increasing c_m causes both η_c and Δp to decrease.

When the compressor runs at a low value of corrected speed, the pressure ratio P_3/P_2 and the density ratio ρ_3/ρ_2 are both lower than the design value. The areas of the annuli at the entrances to the different stages

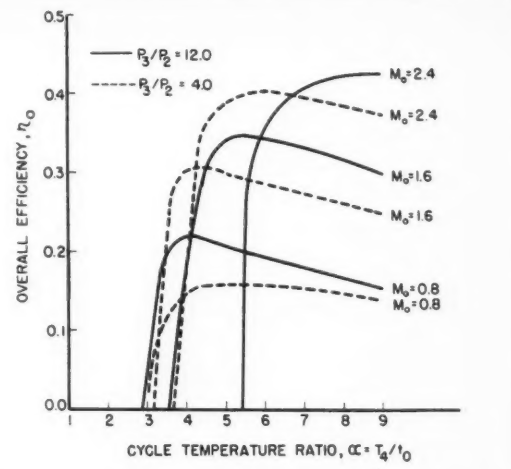


Fig. 5. Overall efficiency as a function of cycle temperature ratio.

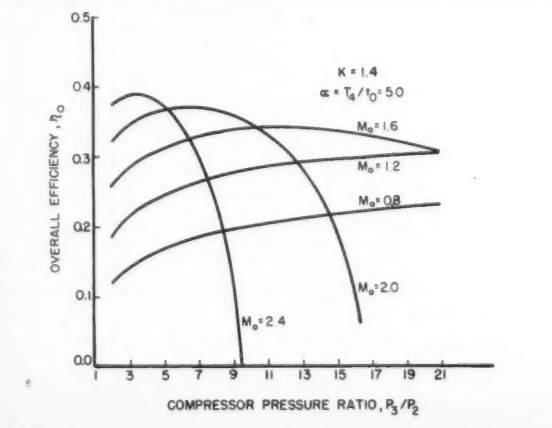


Fig. 4. Overall efficiency as a function of compressor pressure ratio.

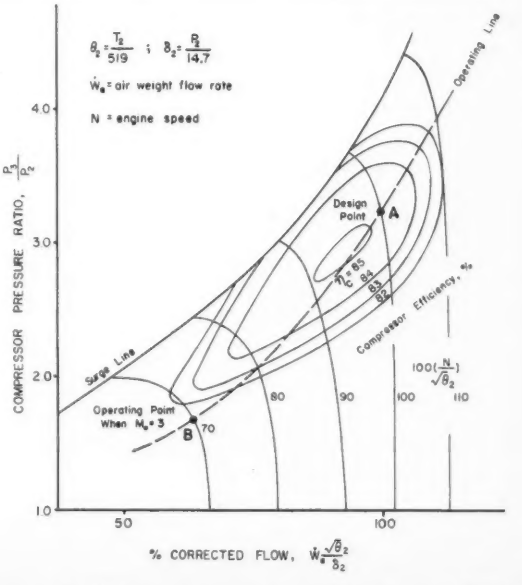


Fig. 6. Typical compressor characteristic diagram showing important operating line.

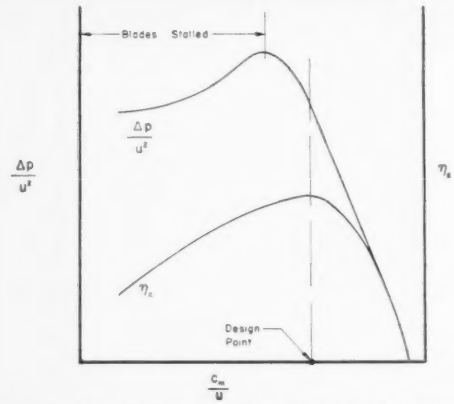


FIG. 7. Performance characteristics of an axial flow compressor stage. (Δp = pressure rise, u = peripheral speed of rotor tip, c_m = meridional component of absolute velocity of air.)

are fixed, and their dimensions are based on the design point values for P_3/P_2 and ρ_3/ρ_2. Because of the reduced flow, the earlier stages are obliged to operate with a velocity ratio which is much smaller than the design value, which forces them into the stalling region. On the other hand, the later stages operate with a much larger velocity which tends to cause the flow to become choked.

The extent to which the early stages of a compressor can be operated with an angle of incidence larger than the design value without stalling its blades is a criterion of the adequacy of the compressor for the desired high flight speed operating point. The extent to which the angle of incidence can be increased without stalling the blades depends upon the design point pressure ratio. A high pressure ratio compressor cannot tolerate much change in corrected speed without the early stages becoming stalled. A greater change in corrected speed can be tolerated if the design pressure ratio is relatively low.

It appears therefore that, if high flight speeds are required with the large reduced corrected speeds, then the compressor must be designed for a lower peak pressure ratio. This means that, to achieve satisfactory operation at the supersonic flight speeds, the engine will operate with lower than current cycle pressure ratios under subsonic flight speeds with somewhat increased specific fuel consumption. Because of the restrictions imposed by the operating characteristics of the air compressor, it is impractical to design a simple jet engine that will deliver simultaneously the high pressure ratio needed to give good performance at subsonic cruise and the broad operating range required for high supersonic flight speeds.[9]

To overcome the problems introduced by increasing the operating range, the compressor design will have to be complicated by introducing one or more of the following corrective devices:

(1) Means for adjusting the angular setting of the inlet guide vanes.

(2) Means for opening a vent in the middle section of the compressor so that more air can pass through the early stages.

(3) Means for operating different portions of the compressor at different speeds.

(4) An arrangement which permits operating the compressor at more or less constant corrected speed.

There are limitations to the usefulness of each of the aforementioned schemes. Undoubtedly some combination of them is probably the better solution. The most suitable combination will depend primarily upon the application of the engine. If the engine is to be applied primarily for supersonic flight, its problems will be reduced if the design pressure ratio is kept as low as is practicable. If the engine is required to operate with good subsonic specific fuel consumption, the design pressure ratio will have to be increased, thereby requiring employment of some combination of the corrective schemes discussed. Of course, consideration must be given to the manner in which the weight of the engine is affected by the different corrective combinations.

It should be noted that, in addition to the mismatching discussed above—which was based on one-dimensional considerations—problems due to radial mismatching arise because of the reduction in the hub-to-tip ratio of the compressor to obtain the large airflow capacities required for supersonic flight.

Combustion Problems

Some of the combustion problems encountered in bringing the turbojet engine to its present state of development will appear in a more intensified form as the turbojet engine for achieving supersonic flight is being developed. The problems will arise primarily from the necessity of conducting such flights at the highest possible altitudes.

For a given combustion pressure, ignition of the combustible mixture is possible only over a limited range of fuel-air ratios, near the stoichiometric ratio. As the static pressure of the combustion air is reduced, the range of ignitable mixtures decreases, and the rich and lean inflammability limits tend to approach each other. At some low value of the pressure, which will be termed the *critical combustion pressure*, the two limits coincide, and, if the pressure is decreased further, no ignition or combustion of the fuel-air mixture is possible. It has been assumed in the foregoing that the fuel-air mixture is static and at a constant temperature while its pressure is being reduced. Although the exact value of the critical combustion pressure is a function of the apparatus wherein the ignition experiments are conducted, the general considerations are applicable to actual combustion.

In general, the efficiency of a given combustion system depends upon the following:

(1) The static pressure at the inlet to the combustor.

(2) The static temperature at the inlet to the combustor.

(3) The air velocity at the inlet to the combustion system.

As to be expected, the combustion efficiency increases with the pressure of the inlet air. Consequently, to obtain satisfactory values of combustion efficiency at the higher than current operating altitudes, where supersonic flight must be conducted, the static pressure of the inlet air must be raised. Increasing the flight Mach Number to supersonic values will tend to raise inlet static pressure to satisfactory values.

Increasing the temperature of the air entering the combustor aids the vaporization of the fuel, with the result that the combustion efficiency is increased. It is to be expected that operations at high flight speeds will aid the combustion process as far as the effect of air inlet temperature is concerned. As pointed out earlier, however, the high air inlet temperatures decrease the temperature rise which can be achieved because of the limitation on the turbine inlet temperature.

In most engine designs, the cross-sectional area of the combustion system is limited by the diameter of the compressor. Consequently, the average velocity of the air entering the combustion system is related to the velocity with which the air is discharged from the compressor. The main factors which tend to increase the velocity of the air entering the combustor are a low compressor pressure ratio and larger airflows per unit of frontal area of the engine. Both of these factors are expected to be incorporated in turbojet engines for supersonic flight.

Increasing the air inlet velocity decreases the combustion efficiency, and, with low values of air inlet pressure, the flame *blows out* at relatively low air velocities. At the high air inlet pressures representative of supersonic flight conditions, the combustion efficiency is improved; but here too it decreases with increasing air inlet velocity. Estimates indicate that the combustors for supersonic turbojet engines may have to operate with air-inlet velocities ranging from 120 to 250 ft. per sec., and with such high air inlet velocities it will be difficult to achieve good combustion efficiencies at the higher supersonic flight speeds.

Another problem which may be considered as a combustion problem arises from the aerodynamic heating of the aircraft at high supersonic speeds. Undoubtedly, the fuel for the engine will be utilized as a heat sink for cooling purposes. Consequently, the combustion system, including its injection system, must be capable of utilizing the heated fuel in an efficient manner.

Exhaust Nozzle

At supersonic flight speeds, the ram pressure ratio becomes so large that the pressure ratio acting on the exhaust nozzle may be as much as 18 to 1. To obtain complete expansion of the exhaust gases, a converging-diverging nozzle is required. Unfortunately, at nozzle pressure ratios lower than the design value, a fixed geometry converging-diverging nozzle operates with considerable overexpansion which causes a large reduction in the possible thrust output of the engine. This will be particularly serious at take-off. To obtain satisfactory engine performance with a converging-diverging nozzle, it must be possible to vary the area ratio of the nozzle. Since afterburning is apt to be employed in a supersonic turbojet engine, it must be possible to vary the throat area of the converging diverging nozzle. From engine performance considerations it is desirable that both the throat and the exit area of the exhaust nozzle be capable of being varied independently. This, of course, introduces some difficult design problems from the points of view of weight and obtaining good internal flow characteristics for the nozzle.

Research and Development Problems

Summarizing, the major research problems which must be solved in developing the turbojet engine for supersonic flight speeds are those pertinent to the accomplishment of the following objectives:

(1) The development of efficient supersonic and subsonic diffusers having a variable inlet area.

(2) Efficient, higher pressure ratio per stage air compressors, with larger air induction capacity and low weight.

(3) Efficient turbines which can be operated safely and reliably at substantially higher inlet temperatures than are currently permissible.

(4) Combustion systems which will be efficient over a wide range of flight speeds and altitudes, with higher inlet air velocities and lower inlet air pressures.

(5) Efficient, lightweight, variable geometry converging-diverging exhaust nozzles.

In closing it might be of interest to mention that certain combination types of engine have been suggested for achieving supersonic flight. For example, performance can be made to be more or less independent of flight speed by driving the turbine with gases produced by an independent chemical means rather than from the air compressor. A more conventional approach is a form of by-pass engine wherein a turbojet engine is combined with one or more ram-jet engines.[11, 12]

Conclusions

Current operational turbojet-propelled fighter aircraft are flying at speeds of more than 650 m.p.h., and jet-propelled bombers have speed capabilities well in the 600-m.p.h. range. These high speeds were deemed practically unattainable a few years back. By overcoming the problems that have been outlined, the turbojet engine of the future will have the potentiality of extending the flight speed spectrum of winged aircraft to high supersonic flight speeds.

References

[1] Martin, Glenn L., *The First Half-Century of Flight in America* (The Seventeenth Wright Brothers Lecture), Journal of the Aeronautical Sciences, Vol. 21, No. 2, pp. 73–84, February, 1954.

(*Continued on page 61*)

Louis J. Battan**
University of Chicago

Vertical Scanning Air-Borne Radar for Reducing Hazards of Aircraft Icing and Ground Collisions*

The modification of presently used air-borne weather-radar to permit vertical scanning in the forward vertical plane is discussed, and several radar photographs are given to show how vertical scanning radar can be used to observe cloud top heights, icing conditions, and the topography ahead of and below the airplane.

Introduction

At the present time commercial air lines are making increasing use of air-borne radar equipment. Although the radar sets currently in use can accomplish several observational tasks if properly used, their primary purpose is that of permitting the pilot to circumnavigate areas of severe turbulence.[2, 5] These radar sets utilize antennas having azimuthal scanning and plan-position indication. For many purposes, this type of operation is well suited to meet requirements of an air-borne weather-radar set. However, as will be shown, extremely useful information can be obtained by using an antenna which can also be made to scan the forward vertical plane through the axis of the airplane and perpendicular to sea level. This use of vertical scanning was first suggested by Atlas[1] for getting information on thunderstorm turbulence and has been developed by the University of Chicago.[4] Many air-borne radar sets have a provision for manually changing the elevation angle of the antenna over a limited sector. For example, the elevation angle of the antenna of the C-band radar sets manufactured by Radio Corporation of America can be varied from +10 to −15 deg. If the antenna could be fixed in the forward direction and made to scan automatically in this vertical sector, the radarscope would yield useful information. It would be desirable to make this vertical sector as large as practicable in order to depict as much of the terrain as possible, as well as the tops of large nearby thunderstorm clouds. In order to simplify the design of the equipment and to keep total weight as low as possible, the normal plan-position indicator can be used to present range-height information.

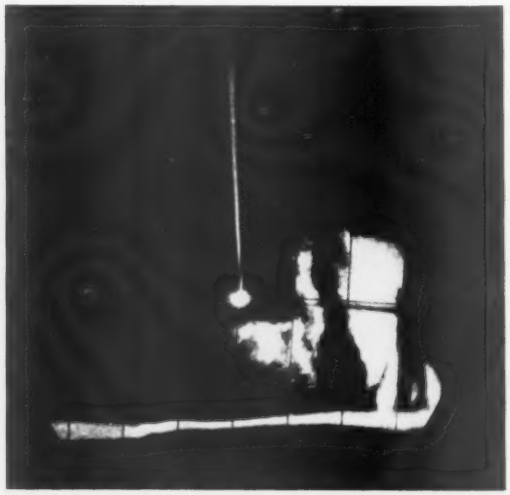


Fig. 1. Photograph of the 'scope of a radar set with vertically scanning antenna. The airplane was flying in a cloud at an altitude 16,200 ft. mean sea level just above a short bright band. A strong thunderstorm echo extending to about 23,000 ft. can be seen on the right. The terrain is at an elevation of about 1,000 ft.

The conversion of the antenna system from one with manual elevation control to one having automatic scanning and the addition of a servosystem to permit use of the same radarscope for horizontal as well as vertical scanning are engineering problems which should not be too difficult or expensive to accomplish.

The original version of this paper was presented at the Meteorology Session, 24th Annual Meeting, IAS, N.Y., Jan. 23–26, 1956, under the title "Implications of Convective Cloud Observations with Regard to Flight Operations with Air-Borne Radar."

* The research reported in this paper has been sponsored by the Geophysics Research Directorate of the Air Force Cambridge Research Center, ARDC, under Contract Nos. AF19(604)-618 and AF19(604)-1388.

** Department of Meteorology.

Cloud Top Measurement

With vertical antenna scanning, the pilot can easily measure the vertical extent of thunderstorm rain areas, Fig. 1.* Of course, the actual cloud may extend several thousand feet above the top of the radar echo, and thus one cannot get an exact measure of its height. However, one can ascertain the order of magnitude of the height of the cloud top. With the available radar sets having azimuthal scan and a manually variable elevation angle, one can make measurements of the radar echo top by varying the elevation angle until the echo disappears. This is time consuming and requires that someone carry out this operation. With vertical scanning, one can read the vertical extent of the echoes directly from the radarscope.

Avoidance of Icing Conditions

In modern air-line operations, aircraft icing is a problem of secondary importance. However, in certain circumstances, icing may still be a dangerous hazard. It is known through the work of Lewis[6] and others that the most heavy icing occurs during flight in the upper parts of convective clouds because of the large concentrations of supercooled water. Serious icing sometimes is also encountered on long flights through supercooled stratiform clouds. It is known that flights through clouds of ice crystals or snow do not suffer from icing. It can be concluded therefore that, if a radar set could differentiate between a cloud consisting almost totally of frozen hydrometeors and one consisting mostly of water drops, one could draw reasonable inferences regarding the icing conditions to be expected. Because of differences of index of refraction, an ice particle has about one fifth the radar reflectivity of a water particle of the same size and shape. For this and other reasons, it can be shown that under certain conditions a radar set can yield useful information regarding icing.

For this problem, vertical scanning would be far superior to horizontal scanning because it enables the pilot to "look" ahead of the airplane and obtain information on the vertical distribution of echo intensity. Under some conditions, the pilot can ascertain whether the hydrometeors above the freezing level are frozen or liquid. When a bright echo band is evident, the pilot can be reassured that above the band the hydrometeors are predominently frozen and that icing is not serious at those altitudes. The appearance of the bright band also tells him the location of the layer at which the falling snow is starting to melt. Fig. 2 is a photograph taken in the vicinity of the northern coast of Puerto Rico while on a flight through a region of widespread rain. The coast of Puerto Rico can be seen about 7 miles away. The airplane was flying at an altitude of 4,100 ft.; the height of the zero-degree isotherm as measured by a radiosonde was at 15,300 ft. It can be seen that the very pronounced bright band is just below this altitude. In this area, one would expect the hydrometeors above the bright band to be snow or ice, and thus there would be no serious icing above the bright band. Also, the lack of prominent echoes above the band indicates that no more than mild turbulence would be encountered.

On some occasions, a bright band is found in some clouds but not in others—for example, Fig. 1. The bright band indicates the height of the freezing level and tells the pilot those altitudes at which icing may be encountered. This technique for obtaining the height of the freezing level would be most useful in regions of extremely sparse upper air data, such as over the oceans.

If the airplane is approaching a region of echo extending over a large area and to altitudes above the zero-degree isotherm (which is estimated from the latest upper-air reports), if a bright band is not evident, and if there is little or no change in echo intensity with height, one would suspect the presence of icing conditions at subfreezing temperatures.

The use of a vertically scanning air-borne radar for the observation and avoidance of icing conditions has never been investigated. It shows sufficient promise to deserve serious study.

Terrain Collision Avoidance

An air-borne radar set should be able to depict accurately terrain obstructions to prevent collisions under conditions of low ceiling and visibility. With "horizontal" scanning and the so-called "safety circle," collision can be avoided using conventional antenna scanning if the radar set is properly adjusted and interpreted.[3, 5] However, with the antenna scanning the

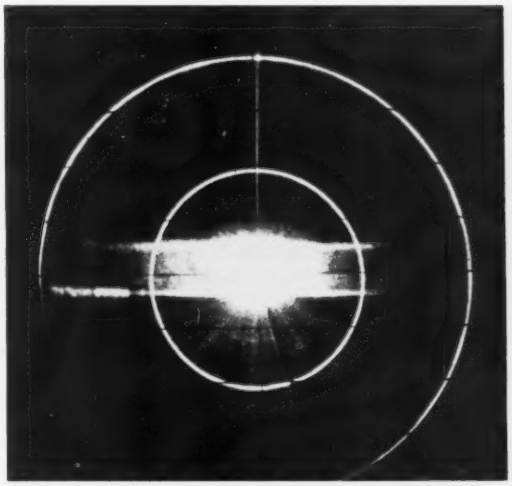


Fig. 2. Photograph taken as the airplane flew west at an altitude of 4,100 ft. just to the north of Puerto Rico. The coast of the island can be seen about 7 miles to the left. The bright band is just below the zero-degree isotherm which was measured at 15,300 ft. Range markers are at intervals of 5 nautical miles.

* All radar photographs in this report were taken of a 3-cm. AN/APQ-13 with its antenna scanning the plane perpendicular to flight path. If the antenna were scanning the forward vertical plane, one would obtain identical information except for blanking of rear of the radar picture by the airplane itself.

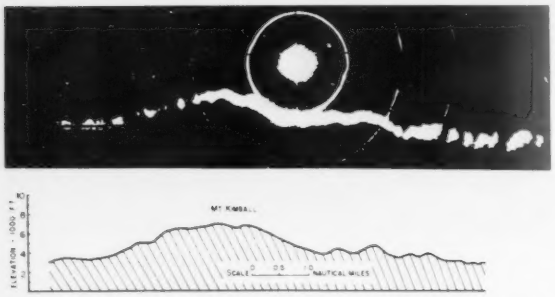


FIG. 3. Photograph taken as the airplane flew at an altitude of 9,800 ft. over Mt. Kimball in the Santa Catalina Mountains in southwestern Arizona. Range markers are at intervals of 1 nautical mile. The lower part of the figure shows a topographic cross section taken from a map of the U.S. Geological Survey which approximately corresponds to the radar cross section.

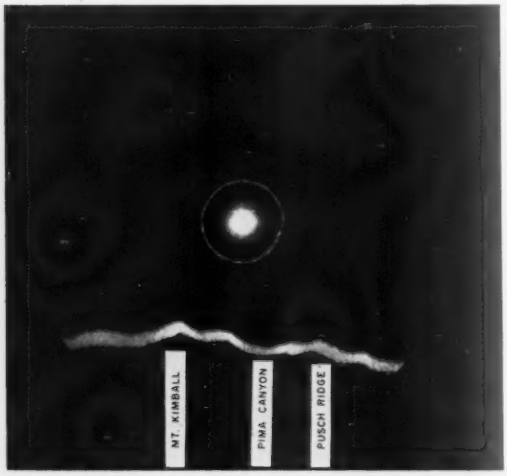


FIG. 4. Photograph taken as the airplane flew over the southwestern end of the Santa Catalina Mountains at an altitude of 19,600 ft. Range markers are at intervals of 1 nautical mile.

vertical sector ahead of the airplane, the problem of terrain clearance is greatly simplified. The topography is displayed on the radarscope, showing the highest points and permitting the pilot to ascend to an altitude which will permit him to fly over them.

The radarscope photographs shown in Figs. 3 and 4 show examples of terrain observations obtained during the flight program of the University of Chicago.[4] From Fig. 3 it can be seen that the radar faithfully reproduced the actual contours of the terrain. The highest peaks are easily observed. Of course the rear of the mountains cannot be "seen" by the radar, but this information is usually of little importance. With the airplane in horizontal flight, the clearance over each mountain is noted and measured. To obtain maximum value from this technique, it is desirable to have as narrow a vertical beam width as possible and pitch and roll stabilization. Many refinements such as the use of a range-height scope could be incorporated to make this system of greater utility, but they are not essential.

CONCLUSIONS

With an air-borne radar having its antenna scanning in the forward plane, it would be possible in many situations to measure the height of the freezing level and to ascertain whether icing would be encountered at certain elevations. The presence of a bright band, which occurs just below the zero-degree isotherm, indicates the predominance of snow and the likelihood of no serious icing above it.

With a vertically scanning antenna, it is possible to obtain an excellent picture of the high points of the terrain ahead of the airplane. The position of the airplane relative to terrain obstructions can be readily noted on the radarscope, and corrective action can be taken to avoid collision.

It is recommended that the modification of present weather-radar sets to permit vertical scanning as discussed in this paper be fully investigated.

REFERENCES

[1] Atlas, D., *Some experimental results of quantitative radar analysis of rain storms*, USAF AMC Report AWNW 7-4, Part I, October 22, 1947.

[2] Ayer, R. W., White, F. C., and Armstrong, L. W., *The development of an airborne radar method of avoiding severe turbulence and heavy precipitation areas of thunderstorms and line squalls*, Final Report on Task No. 1, Contract No. a(s) 9006, BuAer; American Airlines, Inc., September 15, 1949.

[3] Ayer, R. W., White, F. C., and Armstrong, L. W., *The development of an airborne radar method of avoiding collision with terrain, aircraft and other obstacles*, Final Report on Task No. 2, Contract No. a(s) 9006, BuAer; American Airlines, Inc., September 15, 1949.

[4] Braham, R. R., Battan, L. J., and Byers, H. R., *Artificial nucleation of cumulus clouds*, Report 24, Geo. Res. Dir. AFCRC, March 31, 1955. (Also, Meteor. Mono., Amer. Meteor. Soc., 1957).

[5] Harrison, H. T., and Post, E. A., *Evaluation of C-band (5.5 cm) airborne weather radar*, United Air Lines, Inc., Denver, March 1, 1954.

[6] Lewis, W., *Meteorological aspects of aircraft icing*, Compendium Meteor, Amer. Meteor. Soc., pp. 1,197–1,203, 1951.

Ralph W. Allen
Consulting Engineer

A Graphical Method for Determining the Aerodynamic and Economic Characteristics of Turboprop Air-Line Transport Systems

The method is devised to reduce the magnitude of the work and decrease the time required to examine hundreds of possible designs to arrive at the optimum aircraft transport system. Charts are presented for computing most of the quantities, and an example calculation is given.

Symbols

AR	= aspect ratio
C	= cost, dollars
c_a	= cost per lb. of structural weight, dollars/lbs.
C_a	= air-frame structural costs, dollars
c_B	= base cost per lb. of gross weight per airplane, dollars/lbs.
C_B	= base costs, dollars
c_f	= cost per lb. of fuel weight, dollars/lb.
C_F	= fuel costs, dollars
$C_{L_{max}}$	= maximum take-off lift coefficient
c_m	= maintenance cost per lb. of gross weight per hours flown per year, dollars/(lb./hour)
C_m	= maintenance cost, dollars/year
c_0	= specific fuel consumption
c_p	= cost per year per crew member, dollars/year/man
C_p/N	= crew costs, dollars/aircraft
c_{pp}	= cost per lb. of power-plant weight, dollars/lb.
C_{PP}	= power system costs, dollars
C_S	= system cost, dollars
C_S/W_0N	= system cost, dollars/lb. of gross weight/airplane
c_{UL}	= cost per lb. of useful load, dollars/lb.
C_{UL}	= useful load costs, dollars
D	= drag, lbs.
$d_{T.O.}$	= distance to take-off, ft.
f	= useful load factor (a measure of the load actually carried to the maximum possible)
h	= altitude, ft.
I_n	= income
I_{WUL}	= income per lb. of useful load, dollars
K	= income tax factor
L	= aerodynamic lift, lbs.
n	= number of flight crew per aircraft per lb. of gross weight, crew/lbs. aircraft
N	= number of airplanes required for system operation
P_0	= maximum continuous brake horsepower, b.hp.
P_T	= take-off power, hp.
q	= dynamic pressure $(1/2)\rho v^2$, lbs./sq.ft.
R	= range, nautical miles
S	= wing area, sq.ft.
t	= flight time, hours
T	= thrust, lbs.
t_0	= delay time, hours
U	= true airplane utilization per year in hours
U_0	= basic airplane utilization per year in hours
V	= velocity, knots
V_{cl}	= velocity of climb, knots
w_f	= fuel flow, lbs./hour
W_F	= weight of fuel, lbs.
$[W_F/W_0]_{cl}$	= fuel-weight ratio for climb
W_0	= take-off weight or gross weight, lbs.
W_{pp}	= weight of power-plant system, lbs.
W_a	= air-frame weight, lbs.
W_{UL}	= useful load, lbs.
Y	= amortization period, years
ΔI_n	= net gain or profit
H	= climb altitude, ft.
ϵ	= induced drag coefficient factor
η_p	= propeller efficiency
κ	= delay time factor
σ_0	= density ratio at take-off
$\sigma = \rho/\rho_0$	= density ratio
ρ	= altitude density, lbs. sec.^{2}/ft.^{4}

Introduction

In the designing of transport-type aircraft, certain specifications which set forth the functions and requirements of the aircraft must usually be met. The function of most transport aircraft is to carry a certain pay load from one point to another with as low a cost as possible. It is sometimes further desired, and frequently the objective of many transport systems, that a reasonable net gain over costs or profit margin be realized. Transport systems, as used here, are composed of aircraft, flight crew, maintenance, equipment, and airfield facilities.

To satisfy the requirements, the designer must select not only aircraft parameters which provide the means of meeting the performance specification but those which place the aircraft design in competitive relationship with others. In the process of parameter selection, the cost element becomes paramount among the many which must be considered. Frequently time does not permit a thorough analysis. This means that a set

of design parameters must be arrived at as early as possible so that aircraft designs can be rapidly initiated. That analysis method should be employed which shortens the time required to arrive at a reasonably accurate optimum set of aircraft design parameters.

The method described here reduces the time and effort required to accomplish the necessary parametric analysis. The usually lengthy and tedious computations are eliminated by this method, at very little sacrifice in accuracy. By means of simple graphs, the various aircraft design parameters and component costs, as well as total transport system costs, can be obtained. To aid in understanding the method, an example problem is presented.

Description of Method

A method is developed whereby the cost and profit of operating an existing or future turboprop aircraft

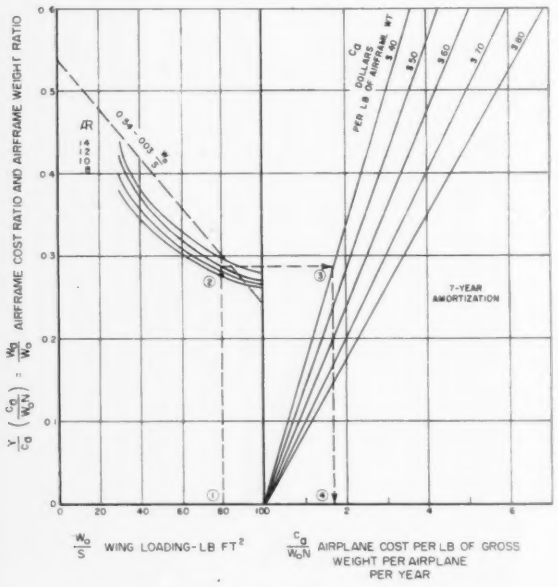

AIRFRAME COST RATIO AND AIRFRAME WEIGHT RATIO
AR = 10
0.54 - 0.03 W/S
7-YEAR AMORTIZATION
WING LOADING - LB FT²
AIRPLANE COST PER LB OF GROSS WEIGHT PER AIRPLANE PER YEAR

Fig. 1. Air-frame cost and weight ratio.

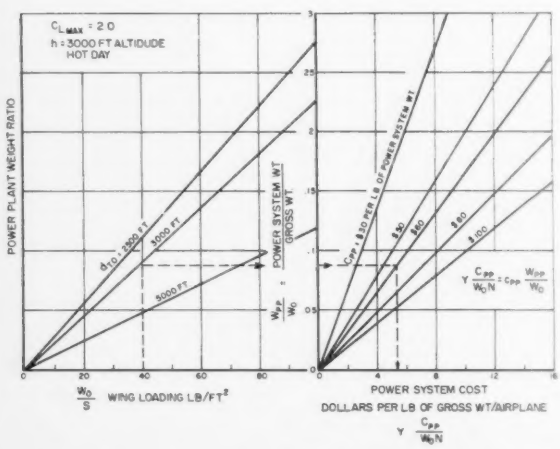

CL MAX = 2.0
h = 3000 FT ALTITUDE
HOT DAY
POWER PLANT WEIGHT RATIO
POWER SYSTEM WT / GROSS WT
WING LOADING LB/FT²
POWER SYSTEM COST
DOLLARS PER LB OF GROSS WT/AIRPLANE

Fig. 2. Turboprop power system weight ratio and cost ratio.

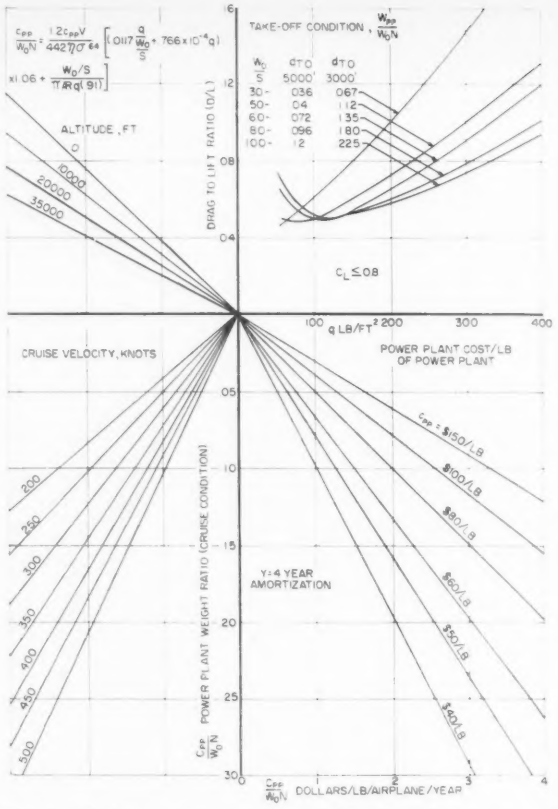


Fig. 3. Turboprop power system weight ratio and cost ratio and drag-to-lift ratio, $AR = 10$.

system (aircraft, maintenance, crew, fuel, and base), as well as the associated aircraft design parameters, can be obtained quickly. The flexibility of the method permits a choice of the cost factors and aircraft design parameters that are related to a particular operation.

Basically, the method utilizes analytical expressions for the drag, weights, power, range, costs, etc., for the transport-type airplane. These expressions are combined and reduced as much as possible to functions containing only the most important variables.

The range of the aircraft is obtained under the same conditions as the Breguet range derivation—that is, assuming constant velocity, constant lift-to-drag ratio, and constant specific impulse.

The development of the power requirements and power system weights is accomplished by either the take-off power or cruise power requirements [80 per cent of the NRP*(b.hp.)]. The power system weight is selected on the basis of the highest power requirements. For higher aspect ratios and lower cruising speeds, the take-off power requirements are greater. At lower aspect ratios and higher cruising speeds and altitudes, the cruise power requirements are usually greater.

The cost equation is expressed in terms of the aerodynamic variables using constant cost factors. The cost equation considers the air frame, power system,

* Normal Rated Power (sea level static).

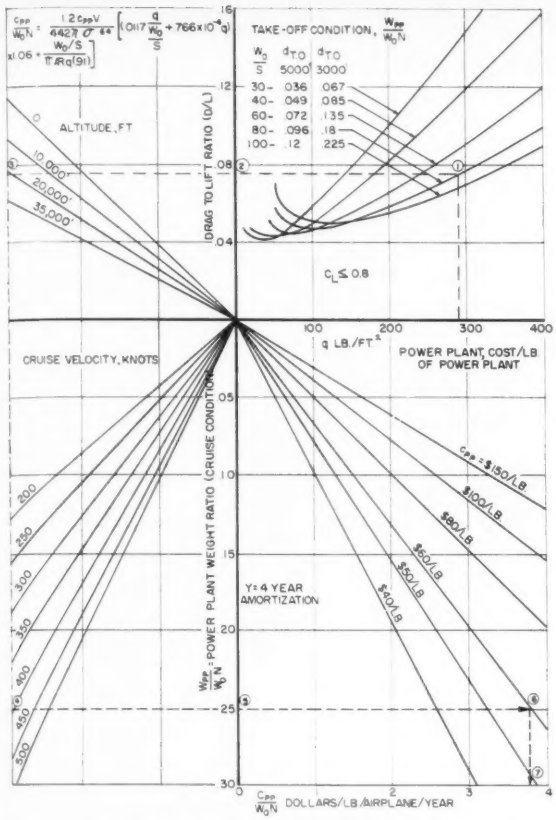


FIG. 4. Turboprop power system weight ratio and cost ratio and drag-to-lift ratio, $\mathcal{R} = 12$.

fuel, flight crew, maintenance, equipment, and airfield facility costs. The fixed costs, such as air frame, power system, and equipment costs, can be amortized over any given period.

EQUATIONS USED IN DEVELOPING CHARTS

Air-Frame Weight per Pound of Gross Weight

$$W_a/W_0 = 0.54 - 0.003\,(W_0/S) \qquad (1)$$

This linear formula is based upon statistical weight data from airplanes having an ultimate load factor of 4.5. The formula is restricted to aspect ratios no greater than 14 and wing loadings within the range of 20 to 100 lbs. per sq.ft.

A closer approximation to the statistical air-frame weight data, although nonlinear, is expressed by

$$W_a/W_0 = 1.78(W_0/S)^{-0.419} \qquad (2)$$

for an aspect ratio of approximately 14. Weight ratios for other aspect ratios are given in Fig. 1.

This formula removes the restrictions imposed on Eq. (1) and is used in the development of the net gain equation. Either formula is adequate, and the choice becomes one of engineering judgment.

The assumption is made that most of the fuel is carried in the wing and that the wing is straight and tapered at a 2:1 ratio (root chord to tip chord) with an average wing thickness of 19 per cent of the chord. (Wing flaps of the Fowler type are assumed on all aircraft.)

Power System Weight per Pound of Gross Weight for a Turboprop Power System

$$\frac{W_{pp}}{W_0} = \frac{12(W_0/S)}{C_{Lmax} d_{T.O.}\,\sigma} \quad \text{lb./lb.} \qquad (3)$$

$$\frac{W_{pp}}{W_0} = \frac{1.2V}{442\eta_p\sigma^{0.64}}\left[\left(0.117\,\frac{q}{W_0/S} + 0.766\times 10^{-4}\,q\right)\times 1.06 + \frac{W_0/S}{\pi \mathcal{A} \mathcal{R} q(0.91)}\right] \qquad (4)$$

Formula 3 bases the power system weight ratio on the take-off power requirements. The power system weight ratio values are given in Fig. 2 and are also tabulated in Figs. 3, 4, and 5. Formula 4 bases the power system weight on the cruise power requirements and is computed from Figs. 3, 4, and 5.

Fuel Weight per Pound of Gross Weight for a Turboprop Power System

$$W_F/W_0 = 1 - e^{-\frac{1.05\,Rc_0\sigma^{0.2}}{325\eta_p}\left[\left(0.117\,\frac{q}{W_0/S} + 0.766\times 10^{-4}q\right)\,1.06 + \frac{W_0/S}{\pi \mathcal{A} \mathcal{R} q(0.91)}\right]} \quad \text{lb/lb.} \qquad (5)$$

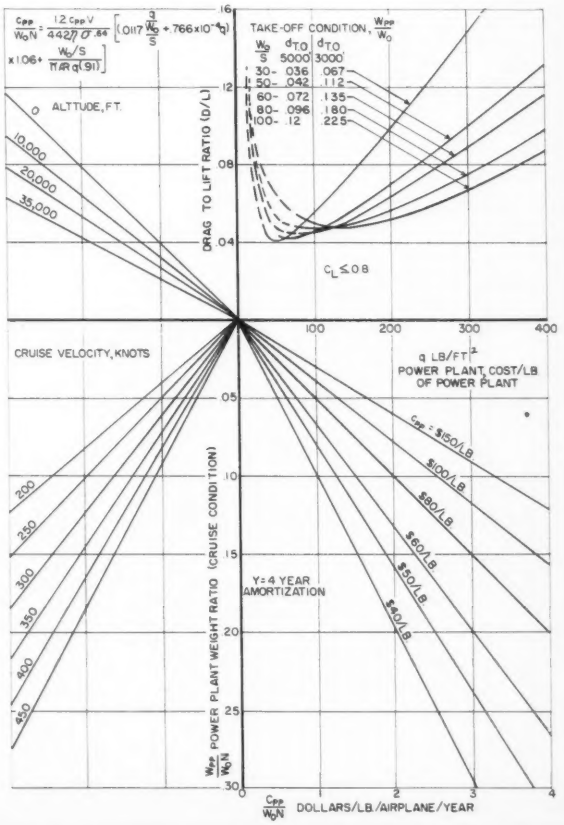


FIG. 5. Turboprop power system weight ratio and cost ratio and drag-to-lift ratio, $\mathcal{R} = 14$.

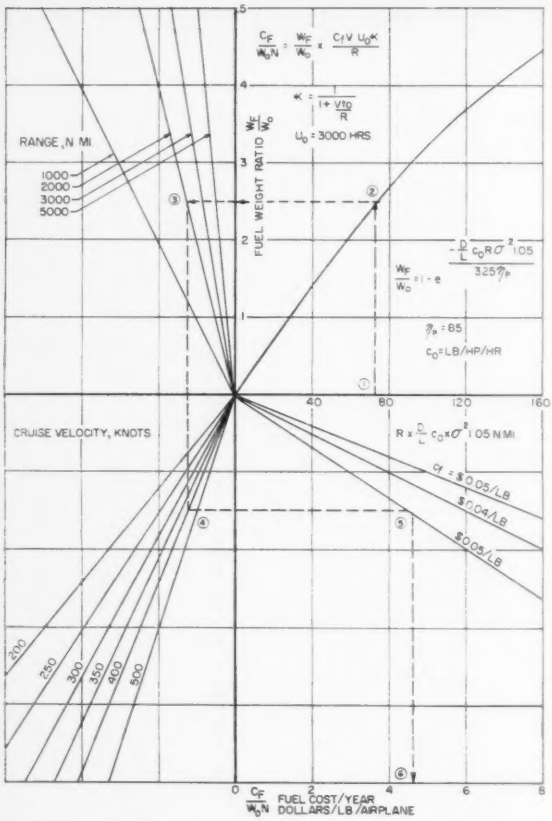


FIG. 6. Turboprop fuel weight and cost ratios based on cruise power requirements.

Formula 5 bases the fuel weight ratio on the cruise power requirements and is derived from the Breguet range formula. The computation of the fuel-weight ratio is obtained graphically from Fig. 6. It should be noted that Eq. (5) is the fuel per pound of gross weight per flight.

The total fuel used per airplane in 1 year is given by

$$[W_F/W_0]_{total} = (W_F/W_0)\cdot(U_0V/R)\cdot\kappa \quad \text{lb./lb./year} \quad (6)$$

The fuel required for climb is expressed by

$$[W_F/W_0]_{cl} = \Delta Hc_0 1.05/V_{cl}\,6080 \quad (7)$$

where ΔH is in feet and V_{cl} in knots. Fig. 7 computes the fuel for climb.

Drag-to-Lift Equation

$$\frac{D}{L} = 1.06\left(0.117\,\frac{q}{W_0/S} + 0.776\times 10^{-4}\,q\right) + \frac{W_0/S}{\pi AR(0.91)} \quad (8)$$

The drag-to-lift equation is based upon statistical data from transport-type aircraft. The data are then formulated in terms of the influential parameters.

This equation is used in computing the power system and fuel-weight ratios. For ease in computation, the nacelle drag term is frequently omitted. To account for it and other miscellaneous unaccountable drag, the parasite drag coefficient is increased by a factor of 1.06. The drag-to-lift ratio is computed from Fig. 3, 4, or 5.

Useful Load to Gross Weight Ratio

The useful load is composed of the crew weights, passengers and/or cargo, communication and navigation equipment, interior fixtures such as chairs and/or tables, and any specialized pieces of equipment.

The useful load ratio W_{UL}/W_0 is computed from

$$W_{UL}/W_0 = 1 - (W_F/W_0) - (W_{pp}/W_0) - (W_a/W_0) \quad (9)$$

Cost Equation

The cost is the sum of the air frame (C_a), power system (C_{PP}), fuel (C_F), useful load (C_{UL}), airplane maintenance (C_m), flight personnel (C_p), and base facility costs (C_B). Symbolically this is expressed by

$$C_S = C_a + C_{PP} + C_F + C_{UL} + C_m + C_p + C_B \quad (10)$$

The cost components are then expressed either as a function of a mass ratio and cost factor or simply as a constant cost factor. Thus

$$\frac{C_S}{W_0 N} = \frac{c_a}{Y}\frac{W_a}{W_0} + \frac{c_{pp}}{Y}\frac{W_{pp}}{W_0} + c_f\frac{U_0V}{R}\frac{W_F}{W_0}\kappa + c_{UL}\frac{W_{UL}}{W_0} + c_m U_0 + c_p n + c_B$$

dollars/lb. of gross weight/airplane/year (11)

All cost factors are assumed constant during the period under consideration.

The air-frame cost, Fig. 1, consists of the cost of the wings, tail, body, control surfaces, landing gear (multiple-wheel bicycle gear), interior furnishings, electrical or hydraulic gear used for various air-frame functions

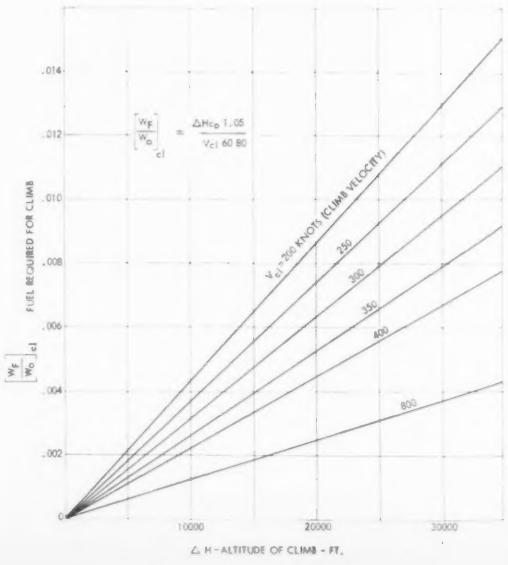


FIG. 7. Fuel required for climb.

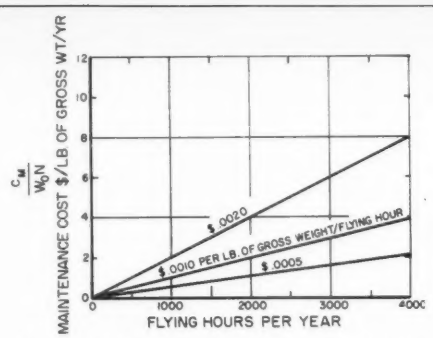


FIG. 8. Airplane maintenance cost, dollars per lb./airplane/year.

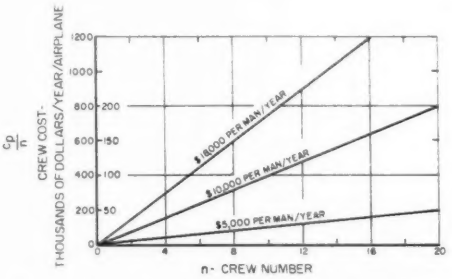


FIG. 9. Crew cost, dollars per lb./airplane/year.

(including the hydraulic pipe and electrical lines), and minimum instruments and controls (excluding special radio and navigation gear).

The power system costs (Figs. 2, 3, 4, or 5) include the cost of the engine with accessories, starting equipment, fuel and oil pumps, and engine nacelles.

Fuel costs are determined on the basis of power requirements and length of operation for a yearly period. The power requirements for computing the fuel costs are selected from the cruise power condition. Fig. 6 graphically determines the cost based on cruise condition.

The cost of the useful load depends upon the particular cargo carried and the circumstance of the operation. If the operation is passenger carrying, then the cost of the seats and tables should be included, or, in the case of cargo aircraft, any specialized equipment should be charged to the useful load cost. In many operations there are no useful load costs involved. In other operations the cost might be considered as the cost of insurance on the useful load; if the useful load is equipment designed for a particular function, it has a certain fixed cost. Whatever the function of the useful load, the effect of its cost can be considered in the system, provided the cost per pound is known.

Maintenance cost (Fig. 8) considers the cost of maintaining the aircraft in operational condition. This includes both material and labor and is expressed in terms of the cost per flight hour per aircraft; the total maintenance cost is then the product of the cost per flying hour, the total number of flying hours per year, and the number of aircraft employed.

Personnel costs (Fig. 9) refer to the flight crew associated with the aircraft operation. A fixed cost per year per person per aircraft is assigned. The total system personnel cost is found by multiplying the cost per person per year per aircraft by the number of personnel assigned to each aircraft and the number of aircraft employed.

The base cost, or aircraft facilities cost, considers the cost of landing facilities procurement or rental and the maintenance of the facilities, as well as the labor involved. These facilities might further include hangars, storage buildings, machinery, passenger services, system administration, etc. The fixed costs are amortized over a selected time period and combined with the yearly operating costs to form the total base operating cost.

To account for the "turnaround time," or delay time caused by the airplane being inoperative while on the ground during loading and unloading of passengers or freight, the utilization, U_0, is modified by the delay time factor, κ, expressed by

$$\kappa = \frac{U}{U_0} = \frac{1}{1 + (Vt_0/R)} \tag{12}$$

In effect, the factor corrects the basic yearly airplane utilization U_0 to the true utilization U.

The time delay factor is shown in Fig. 10. This factor is also used in the profit determination which follows in the next section.

NET GAIN (PROFIT) DETERMINATION

The commercial operator must frequently balance the cost of the system against the income of the system and attempt to gain an excess of income over cost. Expressing the net profit as ΔI_n, income as I_n, and the system costs as C_S, then

$$\Delta I_n = I_n - C_S \tag{13}$$

The income per year, or revenue from an operation consisting of carrying a useful load from one airport to another, is written as

$$I_n/W_0N = (U_0V/R)\ (W_{UL}/W_0)I_{WUL}\cdot f\cdot\kappa$$

dollars/lb. of gross weight/aircraft/year (14)

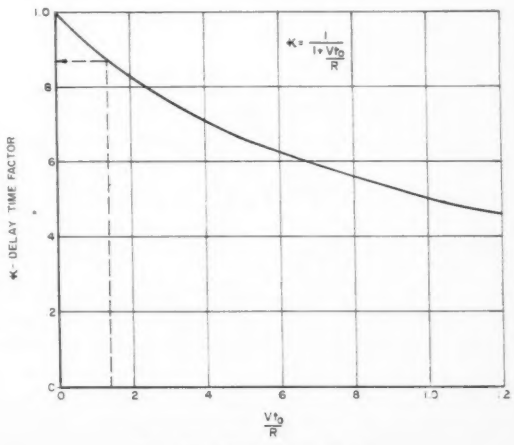


FIG. 10. Delay time factor.

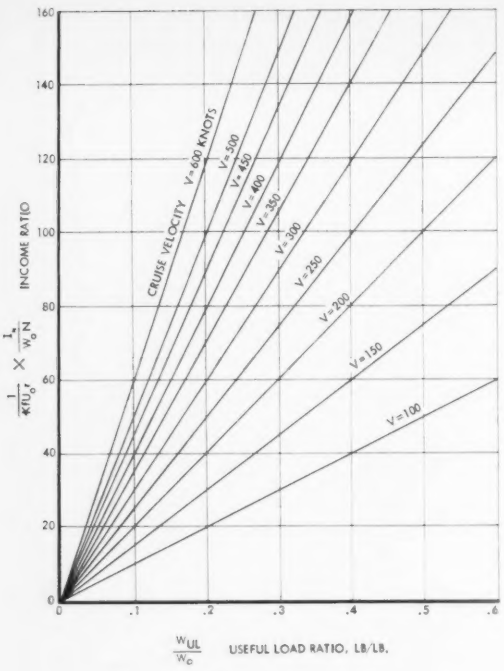


FIG. 11. Revenue computation.

The factor κ, previously defined by Eq. (9), accounts for the "turnaround time" and/or time not used in gainful revenue employment. The useful load factor f is the average number of passengers carried per airplane. The income is computed graphically from Fig. 11.

The ratio I_{WUL}/R in the revenue equation is the revenue per pound of useful load per nautical mile flown and is represented by the symbol r. This ratio is frequently referred to as the revenue per ton-mile.

PROFIT MARGIN

The commercial operator and the investors in the transport system not only are interested in obtaining a profit but are usually attempting to achieve a net profit over costs, or profit margin. This is expressed as $(I_n/C_S) - 1$. It is the profit margin that most of this analysis is directed toward computing.

DISCUSSION OF METHOD

To facilitate comprehension of the procedure, an example problem is given. This problem is by no means the only type that can be solved by this method. Further discussion on analysis scope is given later.

Example Problem

An air line is seeking transport airplanes to fly a newly acquired route of 2,000-nautical mile distance, at a speed of 400 knots, and to carry as much useful load as allowable. The air line is undecided as to whether presently available airplanes will accomplish the task profitably or whether a design of a new airplane should be initiated.

TABLE 1
System Data

Airplane Data		Scheduling and Economic Data	
R_0	= 2,000 nautical miles	t_0	= 1 hour
V	= 400 knots	f	= 0.75
h	= 20,000 ft.	U_0	= 3,000 hours
$\mathcal{R}$	= 12	r	= \$0.32/ton-mile
W_0/S	= 80 lb./ft.^{2}	c_f	= \$0.03/lb.
		c_a	= \$40/lb.
$d_{T.O.}$	= 3,000 ft.	c_{pp}	= \$60/lb.

Specifically, the air-line operator wishes to know his profit margin, the useful load carried, and the gross weight. The known system data are shown in Table 1.

Compute:

W_{pp}/W_0 (weight of power-plant system over gross weight)

Referring to Fig. 4 and following through as indicated by the circled numbers and direction arrows, the values are: (For a $q = (1/2)\rho V^2 = 289$ lb./ft.^{2}, locate the intersection of the q line with the 80 lb./ft.^{2} wing loading curve at ①.)

(1) $[W_{pp}/W_0]_{T.O.}$ = 0.180 lb. (see Fig. 4) for $d_{T.O.}$ of 3,000 ft.

(2) $[W_{pp}/W_0]_{cruise}$ = 0.250 (Fig. 4) ⑤, using a D/L = 0.076 located at ②

Since the power-plant weight requirements are greater for the cruise than take-off condition, the value of 0.250 is used.

(3) Cost of power-plant system

C_{PP}/W_0N = \$3.75 lb./year/airplane (Fig. 4) ⑦

The amortization period is 4 years.

(4) Air-frame weight ratio and cost

W_a/W_0 = 0.29 lb./lb./airplane (Fig. 1) ②
C_a/W_0N = \$1.66 lb./airplane/year ④

(5) Fuel weight ratio and cost

$R \times D/L \times c_0 \times \sigma^{0.2} = 2{,}000 \times 0.076 \times 0.54 \times 0.878 = 72$ (Fig. 6) ①
W_f/W_0 = 0.25 (from Fig. 6). Assuming 10 per cent as fuel reserve,
W_f/W_0 = 0.25 × 1.1 = 0.275 lb./lb.
$[W_F/W_0]_{cl}$ = fuel for climb (from Fig. 7), climbing to 20,000 ft. altitude
$[W_F/W_0]_{cl}$ = 0.0055 lb./lb., assuming a V_{cl} = 340 knots.

Total fuel is 0.275 + 0.0055 = 0.280 lb./lb.

Fuel Costs

From Fig. 6, $C_F/W_0N = 4.6$. The fuel cost is corrected for delay time by applying the delay time factor from Fig. 10. (Note that only the fuel used is costed.)

$C_F/W_0N = 4.6 \times 0.835 =$ \$3.84/lb./airplane/year

(6) Useful load

$$W_{UL}/W_0 = 1 - (W_F/W_0) - (W_{pp}/W_0) - (W_a/W_0) = 1 - 0.28 - 0.250 - 0.29 = 0.18 \text{ lb./lb.}$$

The useful load to be carried is

$$W_{UL} = 140{,}000 \times 0.18 = 25{,}200 \text{ lb./airplane}$$

(7) Maintenance cost

Using a cost factor of \$0.0010/lb./flying hour and $U_0 = 3{,}000$ hours, Fig. 8 gives $C_m/W_0N = \$3.00$/lb./year.

(8) Personnel, administration, facilities, etc., are lumped together and assumed to be \$5.00/lb./airplane/year.

(9) Total costs

$$C_S = C_{PP}/W_0N + C_F/W_0N + C_a/W_0N + C_m/W_0N + (\text{all other costs}) = 3.75 + 3.84 + 1.66 + 3 + 5 = \$17.25/\text{lb./airplane/year}$$

Total cost of system, assuming 20 airplanes in the system, is

$$C_S = 140{,}000 \times 17.25 \times 20 = \$48{,}300{,}000/\text{year}$$

(10) Revenue computation

For the computed useful load ratio of 0.18 and a velocity of 400 knots, the revenue is obtained from Fig. 11.

$$(1/f\ U_0\kappa) \times (I_n/W_0N) = \$72/\text{lb./airplane/year}$$

$$\kappa = 0.835$$

$$I_n/W_0N = \$70 \times 0.835 \times 0.75 \times 3{,}000 \times (0.32/2{,}000) = \$21.0/\text{lb./airplane/year}$$

(11) Profit over cost margin

$$(I_n/C_S) - 1 = (21.0/17.25) - 1 = 0.22$$

Conclusions from the Example Problem

The air line can show a margin of profit (22 per cent). The size of the airplanes depends upon the useful load anticipated; a 140,000-lb. gross weight airplane can carry 25,200 lbs. of useful load. Other conditions being the same, the profit margin remains the same so long as the ratio W_{UL}/W_0 is fixed. Thus, if a useful load of 20,000 lbs. is anticipated, then a gross weight airplane of 111,000 lbs. is required.

The selection of wing loading, aspect ratio, speed, and altitude were satisfactory choices; however, these fortunate selections do not necessarily mean that the resulting profit margin is a maximum. A more comprehensive analysis is required to ascertain this maximum.

Concluding Remarks

The example given is only one of many possible transport system problems that can be solved by this method. The question of what are the airplane aerodynamic characteristics and performance necessary to obtain a maximum profit margin can be answered. Another question might be, "What revenue fare must the operator be required to set in order to make a profit margin?" Further, "What range gives the maximum profit margin for a given altitude?" These are but a few of the questions which this method can help to answer.

More complex analyses, similar to the type of problem just described, are frequently solved by an automatic computer. However, for the situation where single-point information is desired (similar to the example problem), the expense and time to program and compute the problem in the computer are prohibitive. For a more expansive problem consisting of approximately 500 design points (a design point consists of one configuration set), the exhibited method took about 80 man-hours.

Finally, it should be stated that the method developed in this paper to resolve problems of this type is only one of many other possible system analysis techniques. The important fact remains, however, that such simplified techniques are invaluable in approaching and analyzing complex system problems in an expeditious and economical way.

The Problems of the Turbojet Engine . . .

(*Continued from page 51*)

[2] Hurley, W. V., *Influences of High-Speed Flight on Turbojet Engines*, IAS–SAE High-Speed Flight Symposium, New York, March 16, 1950, Paper GER-286.

[3] Silverstein, Abe, *Optimization Studies on Propulsion Systems for High-Speed Aircraft*, Aeronautical Engineering Review, Vol. 13, No. 6, pp. 53–56, June, 1954.

[4] Zucrow, M. J., *Principles of Jet Propulsion and Gas Turbines;* John Wiley & Sons, Inc., New York, 1948.

[5] Krase, W., and Neitzel, R., *Turbojet Engine Design*, Aero Digest, June, 1953.

[6] Zucrow, M. J., *Principles of Guided Missile Design*, Vol. 11, Propulsion Section; D. Van Nostrand Co., Inc., Princeton, N.J., 1956.

[7] Adams, H. W., *Temperature Problems of Equipment in High Speed Aircraft*, Trans. ASME, July, 1955.

[8] Gardner, A. J., *An Introduction to the Thermal Problems of Turbojet Engines for Supersonic Propulsion*, Trans. ASME, July, 1955.

[9] Novak, R. A., *Compressor Problems in High Speed Flight*, Aviation Age, R&D Technical Handbook, June, 1956.

[10] Olson, W. T., Childs, J. H., and Jonash, E. R., *The Combustion Efficiency Problem of the Turbojet Engine at High Altitudes*, Trans. ASME, July, 1955.

[11] Kitsnik, H., *Ramjets for Commercial Transports*, Aero Digest, July, 1954.

[12] Friedman, J., *Ramjet-Turbojet Powerplants Can Extend Flight Regime*, Aero Digest, June, 1956.

IAS News

(Continued from page 23)

nautical Meeting. The award honored Mr. Wislicenus as author of the best paper "relating to the theory or practice in the design or construction of, or research on, aeronautic powerplants or their parts or accessories" presented at an SAE meeting. His paper was on "Principles and Applications of By-Pass Turbojet Engines."

Members on the move . . . .

This section provides information concerning the latest affiliations of IAS members. All members are urged to notify the News Editor of changes as soon as they occur.

Arthur N. Corner (M) has been appointed Project Manager, Missile Test Equipment, for Farnsworth Electronics Company, a division of International Telephone and Telegraph Corporation. He formerly was Assistant to the President and Acting Director of Engineering, Electronics Corporation of America.

Franklin P. Durham (M), Professor of Aeronautical Engineering at the University of Colorado, has been named Head of the Aeronautical Engineering Department. He recently returned to the University after 15 months as a Staff Member, Nuclear Propulsion Division, Los Alamos Scientific Laboratory.

Marcy B. Fannon (M) has been promoted to Assistant to the Director of Flight Operations of Trans World Airlines. He formerly was Manager of Aircraft Performance on TWA's Engineering Staff.

Comdr. Carl O. Holmquist, USN (M), Senior Engineer, Flight Test Division, Naval Air Test Center, Patuxent River, Md., has been assigned the duties of Chief Engineer of the Division.

Julius Kendall, TMIAS, Vice-President in Charge of Sales for Greer Hydraulics, Inc., at New York International Airport, has been named Vice-President in Charge of the company's new Research and Development Division.

Erich Schatzki, MIAS, has been elected President and Member of the Board of Liberty Products Corporation on Long Island. He formerly was Vice-President.

Eugene B. Jackson (AM), formerly Chief, Division of Research Information, NACA, Washington, D.C., has joined the General Motors Technical Center, Detroit, as Head, Library Department, GM Research Staff.

Paul R. Kluger (TM) has joined the Aerojet-General Corporation, Azusa, Calif., as Design Engineer, Grade A, in its Liquid Rocket Plant, Sacramento, Calif. He formerly was Design Engineer with a New York firm of consultants.

H. Peter Liepman (M) has been appointed Associate Professor of Aeronautical Engineering at the University of Michigan. He will continue as Director of the Department of Aeronautical Engineering's supersonic wind tunnels.

Hua Lin (M), Research Aeronautical Engineer, has been given a leave of absence from the Aeroelastic and Structures Research Laboratory at M.I.T. to serve as Research Specialist, Structural Dynamics Unit, of the Boeing Airplane Company's Seattle Division.

Comdr. James H. Manning, USN (Ret.) (M), former Administrative Officer, Naval Air Station, Jacksonville, Fla., has joined Piasecki Aircraft Corporation in an executive capacity.

Milenko Mitrovich (M), formerly Design Project Engineer, Pratt & Whitney Aircraft Division, United Aircraft Corporation, has joined Avco Manufacturing Corporation, Lawrence, Mass., as Chief of Section, Engineering Design, Research and Advanced Development Division.

Brian Sparks (M), Chief Engineer for the Aircraft Division of Clary Corporation, San Gabriel, Calif., has been made General Manager of the Division. He will continue with his duties as Chief Engineer.

Kirby F. Thornton (M) has been appointed Assistant Manager of Aluminum Company of America's New Kensington, Pa., Sales Development Division. Formerly Chief Engineer of the Division, he is a member of the Editorial Advisory Committee of the AERONAUTICAL ENGINEERING REVIEW.

Comdr. Robert James Trauger, USN (M), is attending the Industrial College of the Armed Forces at Fort McNair, Washington, D.C. He formerly was Head of the Patrol Design Branch, Bureau of Aeronautics, Department of the Navy.

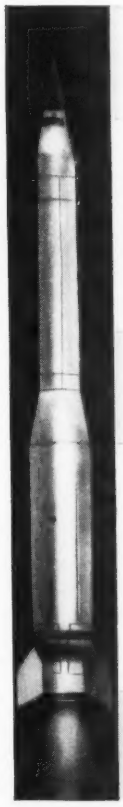
Hsuan Yeh (M) has been appointed Professor of Mechanical Engineering at the University of Pennsylvania. He formerly was Associate Professor at The Johns Hopkins University.

CORPORATE MEMBER NEWS

• **Aeronca Manufacturing Corporation . . .** President John A. Lawler has announced appointment of Stephen H. Badgett as Vice-President in Charge of Operations—one of a series of moves being made to direct more effectively the activities of Aeronca to its greatly developing growth and responsibilities in the field of manufacture of assemblies, major components, and parts for defense contractors. Mr. Badgett heads the principal of three new divisions established by regrouping of numerous departments. Other divisions are Technical Services and Administrative Services.

• **Aerophysics Development Corporation** announces development of a two-stage research rocket reaching almost seven times the speed of sound in 2 sec. Called the Hypersonic Test Vehicle (HTV), it will gather data at hypersonic speeds. Joining in the announcement were Headquarters, USAF, Wright Air Development Center and Curtiss-Wright Corporation. Fifteen of the rockets have been fired and tested at ARDC's Holloman Air Development Center, Alamogordo, N.M. Eleven solid-propellant rockets power the HTV; seven are in the first stage, four are in the second. It is fired from a 16-ft. portable launcher. Work on the HTV Contract was begun in 1953, and the first test flight was in November, 1954. The project at Aerophysics Development Corporation was initiated by William Bollay, ADC President and Technical Director, a Fellow of the Institute. James Kendrick, AFIAS, did preliminary design work. Project Engineer is David Shonerd.

• **Aeroquip Corporation,** leading producer of Flexible Hose Assemblies with Detachable, Reusable Fittings and Self-Sealing Couplings, has developed a new Self-Sealing Aircraft Coupling to meet require-



"LIFE INSURANCE" The preservation of the peace and security of this nation depends upon two things: Our diplomatic wisdom in a troubled world, and the power to protect ourselves if peaceful negotiation should fail.

Point 2 is part of *our* responsibility. This is the Martin-U.S. Air Force TITAN program... one of the most advanced and critically important development projects in America today... an Inter-Continental Ballistic Missile conceived in peace and dedicated to the proposition that no aggressor shall ever take the life of this country.

MARTIN
BALTIMORE · DENVER

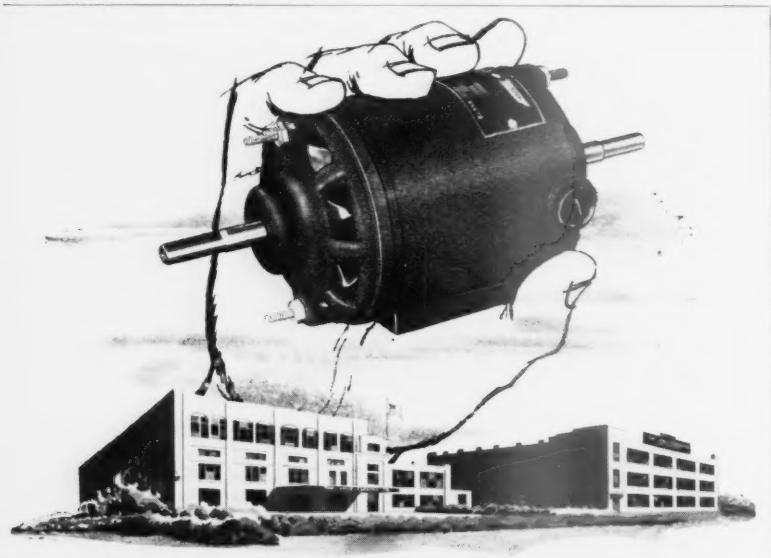
ments of Proposed Military Specification Mil-C-25427. Designated as Series 3200, it is designed for use on air-frame and aircraft engine hyraulic systems with temperatures up to 275°F. and maximum pressures of 3,000 psi. A bulletin on the new coupling may be obtained by writing to Aircraft Sales Department, Aeroquip Corporation, Jackson, Mich.

• **Allis-Chalmers Manufacturing Company . . .** Introduction of new one- and two-groove "Magi-Key" sheaves for quick and easy speed adjustment of "Texrole" V-belt drives in A and B sections has been announced. Designed for low horsepower applications, the "Magi-Key" sheave provides for increased maximum design horsepower. Keys transmit all rotational torques—i.e., from shaft to hub and hub to discs. Set screws no longer bite into threads. Further information is in *Bulletin 20B8524*, copies of which are available on request from the company at 1227 S. 70th St., Milwaukee, Wis. . . . J. F. Costigan, who started his career with the company in 1918 as a machinist, has been appointed Assistant Director of Manufacturing of Allis-Chalmers Industries Group. . . . .Construction features of the "Texrope" grommet V-belt which provide 20 to 50 per cent longer life than ordinary belts are described in a new bulletin, *20B6497C*, available at the address above.

• **Aluminum Company of America** draws on 40 years of forging experience for facts and figures presented in its latest publication, *Technical Data on Alcoa Hand Forgings*. Copies are available by writing on company letterhead to Room 787, Alcoa Building, Pittsburgh 19, Pa. The booklet answers questions of designers, engineers, and purchasing agents seeking the high-strength, low-weight advantages of aluminum for parts of limited production. . . . Production of aluminum-alloy hand forgings with a long-sought low level of internal stresses has been announced by the company. The development, made possible by a new tempering process, fills a decades-old need in aviation and other industries. Immediate advantages are sharply reduced machining and straightening time, with resulting economies in production costs. Internal stresses in finished parts are reduced to a previously unobtainable low point. . . . An aluminum oil filter that can be changed in minutes without tools promises to outmode conventional automobile oil cartridge units. It was conceived and produced by Wix Corporation of Gastonio, N.C., in cooperation with Alcoa.

• **Amphenol Electronics Corporation** has announced the appointment of Richard P. Thornton as Marketing Manager for the Aircraft and Guided Missile Industries. . . . The company is participating in a novel program designed to keep it abreast of latest technological developments in the field of electronics on the European continent. President Arthut J. Schmitt explained the firm's role in the program, which is known as the European Technical Observation Group and is conducted by the Armour Research Foundation of the Illinois Institute of Technology of Chicago. "Under the Armour program," Mr. Schmitt said, "we are given the opportunity to sponsor a trained observer experienced in our particular industry who will represent our interests while in Europe. Working from a headquarters in Europe, the observer's responsibility will be to visit prominent manufacturers and research organizations throughout Europe, review technical papers, attend all significant trade meetings and seminars, visit expositions and, in general, obtain all information of a technical nature that would be of interest to Amphenol."

• **Bell Aircraft Corporation . . .** About 350 military, aviation, and electronic industry representatives attended a 2-day engineering conference in Fort Worth in September. Bell's Helicopter Division at Forth Worth and Douglas Aircraft Company of El Segundo, Calif., made individual progress reports to the conference on the accomplishments of their respective helicopter and airplane long-range instrumentation engineering projects. Purpose of the two parallel studies, coordinated by the aircraft companies under ONR contracts, is to simplify the cockpits of tomorrow's aircraft so as to take full advantage of both the machine's and man's abilities. At Bell, engineers are conducting basic research to determine accurately what information is required by the pilot to operate helicopters under all conditions and how this information best can be presented to the pilot. . . . Harvey Gaylord, of Fort Worth, Vice-President and General Manager of Bell's Helicopter Division, has been elected a Director of the corporation.



CUSTOM-BUILT USE-ABILITY...
for your motor-driven products

Exceptional performance and dependability go with useability in Lamb Electric Motors because they are:

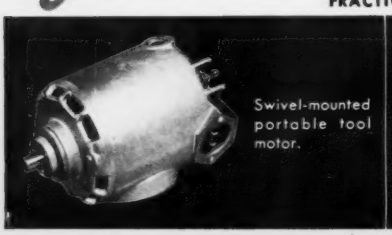
(1) "tailored" to the exact requirements of an application.
(2) built of quality materials by precision-minded personnel.

Our company is equipped and organized to *custom-manufacture on a volume basis;* hence high quality and controlled costs go hand-in-hand.

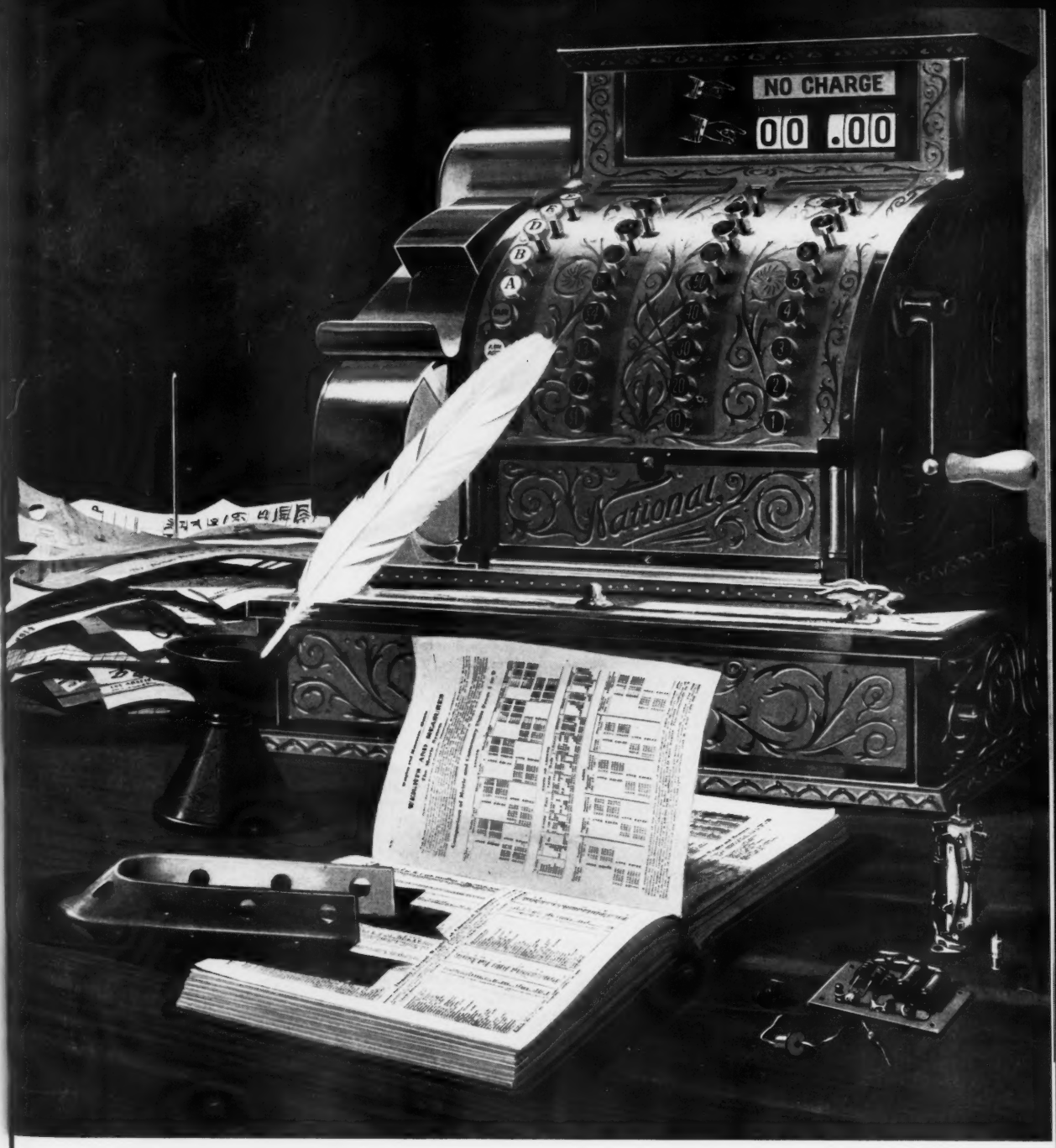
We would like to discuss these advantages with you for *your* new and redesigned products.

THE LAMB ELECTRIC COMPANY • KENT, OHIO
In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario

Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**


Swivel-mounted portable tool motor.

Aircraft de-icing pump motor.



DOLLAR ENGINEERING—Advanced aerial weapons bearing the Northrop name are developed to achieve maximum economy through ease of production, maintenance, and operation. A notable example is the new supersonic trainer now being developed by Northrop for the U. S. Air Force. Light in weight and low in cost, this airplane embodies a basic concept which can result in a whole new family of effective aerial weapons, all linked by the same principle of simple and economical design. Since national defense dollars and national manpower are in short supply Northrop will continue to introduce the dollar into the engineering equations; will continue to employ "dollar engineering" in using the best science and technology to create the *low-cost* solution to a national defense problem and produce more Air Force per dollar of national defense budget.

NORTHRO

NORTHROP AIRCRAFT, INC. · HAWTHORNE, CALIFO

Pioneers in All Weather and Pilotless Fli

Though fabrication of the Douglas DC-8 is well under way, the giant wooden mock-up of the huge air liner *(above)* still has important contributions to make toward the ultimate products. Only one wing is required for the mock-up. The tail cone and empennage will still have to be attached to the "stand-in" pictured. The "Eight" is scheduled to fly in 1958.

• **Bendix Aviation Corporation** has purchased a 40 per cent interest in Computing Devices of Canada Limited, of Ottawa. The purchase agreement includes a sales and licensing agreement under which the Ottawa firm will handle numerous Bendix electronic products and missile components and will exchange engineering developments. In 1955, Bendix acquired a 70 per cent interest in Aviation Electric Limited of Montreal. The CDC agreement, Bendix announced, completes a program to establish a close working relationship between the three Canadian concerns and the corporations' United States divisions.... New electronic developments ranging from radar to radio were shown to military and industrial officials early in October when the corporation unveiled its new Advanced Engineering Center in Baltimore. Latest in a series of new facilities in a $15 million engineering expansion program affecting several divisions, the new Center provides 100,000 sq.ft. of air-conditioned space for technical and laboratory projects covering guided missiles, ground and air-borne radar, aviation communications, and mobile 2-way radio systems. About 400 divisional engineers engaged in creative technical and laboratory projects are being transferred to the new Center from the main Bendix plant, nearby.... The Pacific Division has announced that a fully developed navigation and potential air traffic control system is available now to handle the rapidly growing use of the airways. The system, known as the Bendix-Decca Navigator System, was developed in Great Britain by two Americans and was used first in the Normandy invasions. It is in use in most of the European area, the Division said, and covers over 2 million square miles of land and sea area. The system operates on low-frequency radio waves in the range of 100 kc. and is usable behind hills, in valleys, beyond line-of-sight, and below the curvature of the earth. Good reception and high accuracy are provided from ground level to the highest altitudes. ... A compact, manifolded mounting base for a hydraulic missile guidance system package in which all external interconnected plumbing lines have been eliminated is in production at the Pacific Division. It was designed for the Convair Terrier Missile and has lateral passage lines which lie in three different levels. The package contains 18 components, all of which are mounted on this manifold and interconnected with 15 ft. of "integral plumbing." ... Kirke W. Marsh has been appointed Corporation General Project Manager on a major guided-missile project, the Pacific Division has announced.

• **Boeing Airplane Company...** Establishment of a new position as Director of Sales and appointment of Thomas A. Nelson to the post have been announced by J. E. Schaefer, Boeing Vice-President and Wichita Division General Manager. The appointment became effective September 27. Mr. Nelson will report directly to N. D. Showalter, Assistant General Manager.... According to a CAA report, the Boeing 707 performed like a champion on September 24 when various flight conditions were demonstrated for a group of CAA officials headed by Acting Administrator James T. Pyle at Seattle. The report says that the 707 proved its maneuverability remarkably well on approach, easily demonstrated its controllability at 180 m.p.h. (the speed limit CAA applied in the experimental "high density" air traffic control zone at Washington), proved that it can be fed easily into a final approach from a holding pattern offset to one side (this was done by a simulated emergency descent at 14,000 ft. per min.), and displayed the accuracy of its navigational equipment. The 707 also satisfactorily turned off from the runway at a 30-deg. angle, while moving at well over 70 m.p.h., on a surface less smooth than a standard taxiway. Mr. Pyle said he was "most impressed with" the aircraft. ... The company has observed the first anniversary of its initial order for commercial jet transports. As of October 13, the company had orders or letters of intent for a total of 134 of the planes.

• **Douglas Aircraft Company, Inc....** The backlog of orders for the DC-8 jet air liners stands at 115 following placement of an order for a third "Eight" by Swissair, according to J. W. Clyne, Douglas' Director of International Sales. The plane will be delivered in 1961 and will cost about $6,000,000 exclusive of spare parts. Swissair's previously ordered DC-8's are due for delivery in 1960. All three will be powered by the Pratt & Whitney JT4 turbojet engine, known in the military version as the J-75.... A second Douglas C-133A turboprop cargo transport has arrived at Edwards AFB to undergo flight testing. This first of the C-133's has been engaged in an extensive flight-test program since April.... With delivery of the last AD-6 to the Navy, the Skyraider production lines at Douglas' El Segundo Division are being devoted to the AD-7, latest in the Skyraider series. In continuous production since its first flight on March 18, 1945, the AD Skyraider has become one of history's most famous propeller-driven aircraft. More than 3,000 have been built. The AD-7 is similar to its predecessor in outward appearance but has several improvements. Among them are a Wright B-3350 reciprocating engine providing added power and strengthened wings to prolong service life under higher tactical loads. First AD-7's have been delivered to the Navy.

• **The Dow Chemical Company...** Another magnesium-thorium alloy expected to build higher performance into supersonic aircraft and missiles has been announced. The new sheet and plate alloy has been designated HM21XA-T8 and is the second in a series designed to meet a critical defense need—a structural airframe material that combines light weight and strength with the ability to withstand the intense heat generated by friction at supersonic speeds. Company officials said enough HM21XZ-T8 is on hand for immediate evaluation. The first magnesium-thorium alloy—HK31A—underwent industry evaluation for about 3 years. Tests established that it retained good short-time properties above 600°F. and good long-time properties below that temperature. Dow says of the new alloy: It extends the heat range to at least 700°F.; at the 700-deg. level, it will withstand prolonged exposure—as long as 100 hours—with little effect on its properties (it has been tested up to 900 degrees F.); it offers superior resistance to creep at elevated temperatures; and it retains other HK31A characteristics. The new alloy will be shipped from Dow's Madison, Ill., mill to evaluators in the T8 temper—a condition partly responsible for its improved properties. This means that the customer can use the alloy without further heat-treating.

• **Eaton Manufacturing Company...** John C. Virden, a Director of the company for the last 10 years and member of its Executive Committee since 1950, has been elected President of the quarter-billion-dollar producer of automotive, aircraft, and industrial products. The announcement was made by Howard J. McGinn, Chairman of the Board. Mr. Virden, banker and businessman who has headed his own industrial firm (John C. Virden

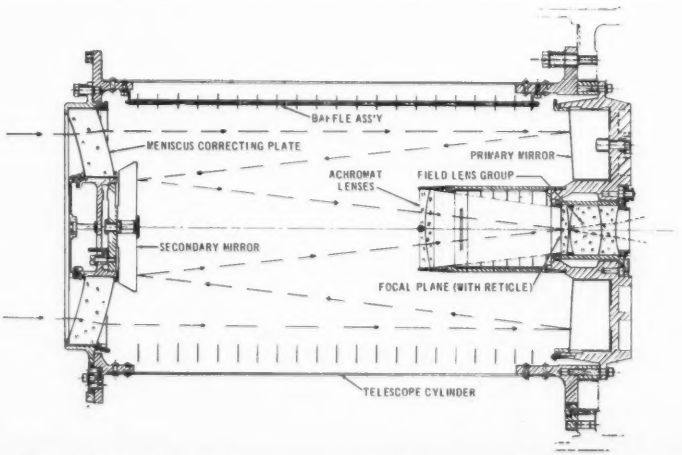
Company, Cleveland, manufacturer of fluorescent and incandescent lighting equipment) since the start of his business career, is Chairman of the Board of Directors of the Federal Reserve Bank of Cleveland and Federal Reserve Agent for the Fourth Federal Reserve District. Upon assuming his new duties, Mr. Virden will relinquish his banking posts and his position as Chairman of the Board of the company bearing his name.

• **Elastic Stop Nut Corporation of America** has developed a full line of reduced height, counterbored self-locking anchor and gang channel nuts to meet requirements of the new NAS680-695 drawings. The new LHTA series is designed with minimum envelope dimensions compatible with performance requirements for structural aircraft applications. . . . The A'G'A Division of ESNA has developed a new line of dial head AGASTAT time-delay relays for time-delay applications requiring frequent time adjustments. Dial markings permit easy calibration for accurate adjustment, and each dial is color coded to identify the timing range. AGASTAT relays are relatively unaffected by wide temperature changes from −65° to +160°F.

• **Fairchild Camera and Instrument Corporation...** A giant telescopic tracker capable of tracing a missile 300 miles away, which shows clearly fast-moving aerial objects in natural color on its scope, has a 400-lb. lens systems developed by Fairchild. The tracker, weighing a ton and a half, was developed at the Army Signal Corps Engineering Laboratories, Fort Monmouth, N.J., and takes black and white photographs of rockets, jets, and other flying objects automatically. Heart of the main optical system is a 40-in., focal-length Cessegrain type of reflective optics. The camera, built and designed by Fairchild, has a capacity of 20 pictures per second, though most of the work has been done at 4 pps. Angular data obtained from the precision scales also are recorded photographically. The main camera uses 70-mm. film, the data camera 35-mm. film. . . . Sherman M. Fairchild, Chairman of the Board, has announced the election of James A. Marohn as Vice-President—Finance. Mr. Marohn was Executive Vice-President and a Director of Magic Chef Corporation of St. Louis and will retain the latter post.

• **Fairchild Engine and Airplane Corporation...** Quebecair, Inc., has become the first air line outside the United States to order the Fairchild F-27 propjet transport. The company has placed a $1.3 million order for two of the 40-passenger, twin-engined aircraft. Deliveries are expected early in 1958. The Quebecair order brings to about 60 the number of F-27's on order and option from Fairchild Engine and Airplane Corporation. . . . Laurance G. Henderson, former legislative assistant to Senator Flanders (R., Vt.), and staff director of the Senate Small Business Committee, has joined the sales staff of the corporation and has been assigned to the Latin American countries. . . . The Fairchild Aircraft Division reports that two Fairchild C-123 Provider transports of the 513th Troop Carrier Group recently demonstrated in Air Force-Army tests that they are capable of parachuting personnel and equipment into combat drop zones, as well as landing men and supplies on the ground in assault-type operations. The C-123 was designed primarily for the latter job. Tests were held at Fort Bragg, N.C.

• **Federal Telecommunication Laboratories,** a Division of International Telephone and Telegraph Corporation, has won the Research and Development Award for 1956 of the Air Force Association's New Jersey Wing. FTL was selected to receive the honor on the basis of outstanding contributions in the field of air navigation, especially in the research and development of TACAN made by FTL. The award was received at the Wing's Eighth Annual Convention in Asbury Park, N.J., on October 13, by FTL's Brig. Gen. Peter C. Sandretto, Vice-President and Technical Director, and Henri Busignies, President, who directed the TACAN program. Included in the 2-day program at Asbury Park was an illustrated lecture by General Sandretto to the Industrial Forum on FTL's electronic contributions to the defense program.



Giant Telescopic Tracker's primary optical system, designed by Dr. James G. Baker and built by Fairchild Camera and Instrument Corporation, uses mirrors as well as lens to trace missiles 300 miles away.

get in on the birth of new ideas

...and see them through. Look into Lear. Time and again Lear is first to conceive the ideas that meet tomorrow's aviation needs—today. Write to Don Cook, Dept. E-21, 3171 South Bundy Drive, Santa Monica, Calif. Excellent openings available in Grand Rapids, Michigan; Elyria, Ohio; Santa Monica, California.

Aerodynamics
Aeronautical design
Aircraft electrical systems
Automatic flight controls
Computers
Communications (aircraft)
Electro-mechanics
Electronic packaging
Flight reference systems
Flight instrumentation
Fractional H. P. motors
Gyroscopes
Hydraulic systems
Magnetic amplifiers
Missile controls
Navigation systems (aircraft)
Process engineering
Pumps (aircraft and industrial)
Radar
Servo mechanisms
Systems analysis
Test equipment design
Transistorized circuitry

LEAR

• **The Firestone Tire & Rubber Company...** Plans for the immediate construction of a new plant for increased production of rubber air springs have been announced by Harvey S. Firestone, Jr., Chairman of the company. The springs, to be marketed as Firestone Airide, will go into volume production in July, 1957, in the new plant to be built in Noblesville, Ind. Mr. Firestone observed that "adoption of the new Airide system in place of the leaf and coil springs now used on some automotive vehicles is the greatest contribution to passenger comfort since pneumatic tires replaced solid tires on motor cars." In addition to its use on trucks, buses, and trailers, Airide has many industrial applications in the cushioning of shock forces.

• **Flight Refueling, Inc....** In a movement underlining rapid mobility under a new concept inaugurated by Tactical Air Command, four groups of military aircraft recently flew to Italy and Germany as a composite simulated air strike force. This was the first time TAC had displayed one of the new self-sustaining units outside the United States. The groups include F-100C jet fighters, F-84F jet fighter-bombers, RF-84F photo-reconnaissance jets, and B-66 jet tactical bombers. All the fighters were refueled in flight using the Probe and Drogue System developed by Flight Refueling, Inc., Baltimore. A squadron of F-100C's flew a 2,891-mile course nonstop from Harmon Air Base, Newfoundland, to Sidi Slimane, Morocco, in 5 hours, 11 min., averaging 565 m.p.h. From Sidi Slimane, they flew to their operational base at Landstuhl Air Base, Germany. A squadron of F-84's flew 3,787 miles nonstop from England AFB, Louisiana, to Morocco in 7 hours, 39 min., for an average speed of 510 m.p.h. The RF-84F flight from Shaw AFB, S.C., covered 4,307 miles in 9 hours, 9 min., for a speed of 473 m.p.h. Both units proceeded from Morocco to Aviano, Italy.

• **The Garrett Corporation...** General K. B. Wolfe, USAF (Ret.), has been appointed Assistant to the Chairman of the Board J. C. Garrett. Mr. Garrett said that General Wolfe will begin work immediately on special top-level assignments currently being projected by the corporation.... W. T. von der Nuell, formerly in charge of engineering for the AiResearch Industrial Division, has been appointed Assistant Chief Engineer, Turbomachinery Planning, for the entire corporation. His former post will be filled by Wilton E. Parker.... The AiResearch Aviation Service Division has acquired a new hydraulic test stand that will check out the oil-flow operation of aircraft valves up to 20 gal. per min. and valve pressure functions up to 3,000 psi. Substantial expansion of the Division's services, at Los Angeles International Airport, is provided by the equipment.... Construction has begun on two new laboratory buildings for the AiResearch Manufacturing Division. They will bring to over 150,000 sq.ft. the total laboratory working area for AiResearch's vast testing, research, and development programs in California and Arizona.... The Division has been given the assignment of providing for passengers' physical comfort and breathing ease

Three new General Electric 165°C. low-current silicon rectifiers.

in the Boeing 707 with complete air-conditioning and pressurization systems. First units are scheduled for delivery early next year.... The smallest heat exchanger ever to come off its engineering boards has been developed by the Division to pressurize and cool the inside of a high-altitude suit in the Douglas F4D jet fighters. The unit weighs less than a pound and is encased in a housing that measures 4 by 3.75 by 2.25 in.

• **General Dynamics Corporation...** Work on a new $2 million high-altitude test facility for aircraft systems, parts, and equipment was scheduled to begin last month at the Forth Worth plant of the Convair Division. Temperatures from −001° to +500°F. will be available, and altitudes up to 100,000 ft. will be simulated. It is expected that the two buildings will be completed during the coming year. The Division also has begun construction of a $225,000 building in San Diego to house detailed mock-ups of the new Convair Model 880. It is scheduled for completion by February 1, 1957.... Initial units of airborne electronic equipment were shipped on September 26 from the new plant established in April in San Diego by the Stromberg-Carlson Division. The equipment consists of a damper amplifier assembly, part of the system used to stabilize flight of supersonic aircraft. Until late September, Stromberg-Carlson production in San Diego was concerned principally with the Charactron shaped-beam tube.

• **General Electric Company...** Stuart MacMackin has been named Counsel for the Defense Electronics Division.... A new series of miniature, 10-kw. silicon rectifiers—capable of operation in an ambient temperature range of from −65° to 200°C.—is being produced at Electronics Park, Syracuse, N.Y. A bulletin describes the product completely.... Formation of a new Missile and Ordnance Systems Department within the Defense Electronics Division has been announced by George L. Haller, AFIAS, Division General Manager. Its headquarters will be in Philadelphia. George F. Metcalf will be Manager.... Headquarters of TEMPO, a new technical planning operation within the Division, will be established in Santa Barbara, Calif.... Engineers of G-E's Metallurgical Products Department believe they have the key in overcoming cutting problems at speeds of 0 to 2,600 ft. per min. by teaming up two cutting tool materials on the same machining setup—cemented carbides and cemented oxides. The new machining technique was demonstrated at the recent National Metal Show in Cleveland.... The Company has announced expansion of its line of 165-deg. low-current silicon rectifiers to include three new types. Developed under an Air Force contract to meet stringent military requirements, they are in full production at the Semiconductor Products Department, Clyde, N.Y. The new rectifiers—RETMA type designated 1N536, 1N539, and 1N540—are rated, respectively, at maximum inverse voltages of 50, 300, and 400 volts. Maximum allowable RMS voltages are rated at 35, 210, and 280 volts, respectively. A bulletin describes the product completely.

• **General Precision Laboratory Incorporated...** Construction has begun on a new Engineering Building in Pleasantville, N.Y.—the second major engineering addition to the concern's facilities over a 2-year period. Increased space will amount to 22,000 sq.ft. Completion of the structure is expected in July, 1957. It will help meet requirements for additional space created by GPL's expanding activities in the field of military electronics and is to provide increased facilities for company engineers and other technical personnel engaged in research, analysis, design, and instrumentation of air-borne navigation and missile guidance systems. GPL is a subsidiary of General Precision Equipment Corporation.

• **G. M. Giannini & Co., Inc....** Two new products, the Model 3416 Free Gyro and the DATEX Model SP-101 Pressure Scanner, are announced by Giannini, of Pasadena, Calif. The company reports its new gyro offers unusual ruggedness and insensibility to mounting and dynamic loads. The instrument features a cast steel frame mounted solidly inside a structural outer shell having an integral c.g. mounting flange. Shock specification is 50*g* in all axes. Drift rate is less than 18 min. of arc per min., and the potentiometer pickoffs which supply outputs up to 70 volts for telemetering and control operations have a linearity of plus-minus 0.5 per cent and resolution of 0.09 deg. A remote electrical caging mechanism automatically returns the gimbals to an accurately fixed reference position. Available as a single unit or as a pair in a Free Gyro Set for indication in the three major axes, the Model 3416 motor is powered by 115-, 200-, or 26-volt three-phase 400 cps voltage. The company reports its Model SP-101 Pressure Scanner introduces new concepts of lower cost and increased accuracy into the field of pressure instrumentation. Designed to enable the measurement of up to twelve pressure sources with only one transducer, the DATEX Pressure Scanner not only reduces the number of transducers required for multiple pressure measurement but can be used to increase accuracy of measurement with presently available components.

• **The B. F. Goodrich Company** has developed a new type of disc brake, incorporating sintered metal linings and newly perfected automatic adjustment for the Lockheed Electra, according to its Aviation Products Division. The Electra, to be in air-line service in early 1959, will use four 13.50-16 24-ply rating tubeless tires on its landing wheels. Brakes and wheels for the new airplane were designed and engineered in the company's aircraft wheel and brake plant in Troy, Ohio, and will be produced there, according to General Manager P. W. Perdriau. . . . Marland J. Kingsbury, who since 1946 has been Office Manager of the wheel and brake plant, has been named Manager of Factory Accounting and Costs for the Aviation Products Division in Akron, Ohio, Mr. Perdriau also announced.

• **Walter Kidde & Company, Inc.** . . . Two new plants totaling 58,000 sq.ft. have been added to the overseas manufacturing and assembly facilities of wholly owned subsidiaries of the Company, of Belleville, N.J. The two plants are valued at $400,000. The first, at Northholt, England, is of modern steel reinforced and concrete design and totals 30,000 sq.ft. More than 400 persons are employed at Northholt in the manufacture of carbon dioxide industrial and marine fire detecting and extinguishing systems, a complete line of portable fire extinguishers, inflation equipment for life rafts and vests, and oxygen-breathing equipment for aircraft and health uses. The second plant was built at Bleckede, near Hamburg, Germany, in 1948 and was acquired by Walter Kidde G.m.b.H. last summer. Totaling 28,000 sq.ft., this plant initially will assemble marine carbon dioxide and smoke detecting systems and Kidde rachel knitting machines. Plans call for it eventually to manufacture Kidde products for the German and continental markets.

• **Kollsman Instrument Corporation** . . . LeRoy D. Allen has been appointed Manager of the Service Engineering Department in a move which Henry N. Droge, Assistant General Sales Manager, said was to keep pace with the rapidly expanding production of aviation instruments and automatic navigation systems. Mr. Allen formerly Supervisor of Field Development Engineers at Kearfott, also will serve as technical adviser of the Kollsman Instrument Training School. Mr. Droge also announced that two important groups have been added to the responsibility of the Service Engineering Department. The first will study service requirements of each new product during its design stages and will become the source for experts thoroughly versed in problems relating to the installation, maintenance, and overhaul of each new production item. The second is a Technical Analysis and Reliability Group, which will initiate and coordinate in-use product reliability information and data from the field. It will maintain automatic record system reliability studies and coordinate these with the Military Product Improvement Program and similar studies conducted by air-line and air-frame manufacturers.

• **Lear, Incorporated** . . . Using an advanced electronic autopilot developed by Lear, top officials of the CAA have made

The Chance-Vought Regulus takes to the air. Precision actuating assemblies for this and other guided missiles are part of Ex-Cell-O's production.

Four typical actuating assemblies precision-built by Ex-Cell-O for planes and guided missiles.

You Can Be Confident of Precision

With Ex-Cell-O Parts or Assemblies

Almost every plane you see streaking across American skies, flies with Ex-Cell-O precision parts or assemblies—precision-built to fulfill ever more rigid design specifications.

From design to final inspection skilled personnel, working with the most complete manufacturing facilities available, build precision into every part and assembly. That's why the aircraft industry has placed confidence in Ex-Cell-O for over 30 years.

For parts or assemblies that meet your most rigid specifications—that meet your delivery schedules—send your print or sketch to:

55-42

XLO

EX-CELL-O for PRECISION

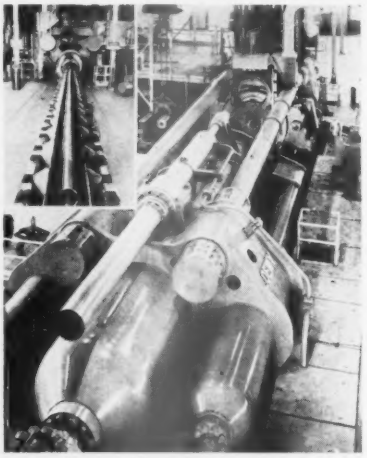
EX-CELL-O CORPORATION • DETROIT 32, MICHIGAN

MANUFACTURERS OF PRECISION MACHINE TOOLS • GRINDING SPINDLES • CUTTING TOOLS • RAILROAD PINS AND BUSHINGS • DRILL JIG BUSHINGS • AIRCRAFT AND MISCELLANEOUS PRODUCTION PARTS • DAIRY EQUIPMENT

many hands-off simulated blind landing approaches in the Boeing 707 prototype. Lear reports that Government pilots were uniformly enthusiastic in expressing their praise of the airplane's performance. . . . An order has been placed for the conversion of Minnesota Mining & Manufacturing Corporation's Lodestar business airplane into a high-performance Learstar Mark II, according to V. B. Benfer, General Manager of the Aircraft Engineering Division. About 40 m.p.h. will be added to the cruising speed of 230 m.p.h., and nonstop range will be nearly doubled, Mr. Benfer said. The same Division is using a "test stand test stand"; the Division has delivered to Rocketdyne Division of North American Aviation a substantial number of mobile pneumatic and electrical test stands for checking out rocket engines without actually firing them. The complexity and high-performance characteristics of the rocket engine test stands required Lear's design and construction of a good-sized auxiliary test stand to check them out. . . . Lear-Romec Division, Elyria, Ohio, announces the Lear-Romec Model RG-15530, three-element lube and scavenge pump for gas-turbine engine oil. The two scavenge element and one lube element pump is suitable for use with petroleum base engine oil or gas-turbine lubricating oil MIL-L-7808. Complete information is obtainable from R. S. Atkinson, of the Division.

• **The Liquidometer Corporation** has issued an illustrated bulletin, *No. 563*, describing its thermistor-type liquid level warning and control system. The bulletin outlines the wide variety of indicating, warning, and control functions for which thermistor-type systems can be used on aircraft. Functions performed by thermistor-type systems include fuel sequencing, wet line detection, and low level warning. Thermistor circuits can also account for normally usable fuel which becomes trapped because of failure of the aircraft's fuel transfer system. Copies of the bulletin may be obtained from the firm, at Skillman Ave. and 36th St., Long Island City 1, N.Y.

• **Lockheed Aircraft Corporation . . .** The Model 1649A Super Constellation, sixth "Connie" in the Constellation series 17-year history, made its maiden flight in October, remaining aloft almost an hour on enlarged 150-ft. wings which Lockheed says give it the greatest nonstop range of any transport—6,300 miles in air-line service. Burt C. Monesmith, Vice-President and General Manager of Lockheed's California Division, said the 1649A will undergo 6 months of flight testing to certify it for air-line service. Deliveries are scheduled for Trans World Airlines in April and for Air France in June. The first flight was programed to include a thorough shakedown to familiarize flight-test personnel with the new "Connie's" handling characteristics and to check functional operation of gear, flaps, and all systems. Aboard were Test Pilots H. R. Salmon and Roy Wimmer, Glenn Fisher as Flight Engineer, and John Stockdale as Flight Test Engineer. . . . Manufacturing Director Don J. Murphy has announced a third giant laboratory building to be constructed on the Missile Division's 22-acre research center in Stanford University's Industrial Park. This new laboratory brings to seven the number of Lockheed structures completed or being built in the San Francisco Bay area and to almost a million square feet the Division's total facilities. . . . Willy A. Fiedler, holder of several high Government awards, has been appointed to the engineering staff of the Division—assigned to a research and development post in the Engineering Branch's Advanced Design Division. . . . William E. Frye, formerly engaged in aircraft navigation and ballistic missile guidance research for The RAND Corporation, has joined the Missile Systems Division Research Laboratories in Palo Alto. . . . Richard Huynen has been appointed Associate Research Scientist in the Electronics Research Department of the Missile Systems Division. C. Roger Moe has been appointed Senior Scientist, and Jean Richard Huynen has been named Associate Research Scientist at the Palo Alto Laboratories of the Missile Systems Division. . . . Alan Andrew, an atomic energy research specialist, has joined the staff of the Nuclear Physics and Engineering Department of the Division, and Eugene E. Crowther has been named new Base Manager of the Division's Flight Test Base at Holloman AFB. . . . High-speed electronic computers used by Lockheed scientists to solve guided-missile problems are working to defeat the nation's number one killer—heart disease. Located at the Missile Systems Division, Van Nuys, Calif., the computers spend their spare moments between missile calculations in a detailed new study of the human heart's activity. The study, it was reported, promises to reveal extensive new knowledge of heart diseases, their earlier detection, and relief. . . . J. P. Lydon, Director of Industrial Relations at the Georgia Division since the plant was activated in 1951, has begun new duties as Director of Administration, succeeding R. R. Kearton, recently named Weapons Systems Manager. . . . Recent appointments in the manufacturing organization of the Division have been R. E. Fitzwilson, to Assistant Director of Quality Control; Mark L. Wilton, to Chief Industrial Engineer; J. P. Leahan, to Manager, Industrial Engineering Department; C. H. Roha, to Division Manager, Purchasing Division (reactivated); F. A. Kanzler, to Manager, Purchasing Department; J. N. Buckley, to Manager, Purchasing Operations Department; and H. W. Sinnen, to Manager, Outside Manufacturing Department. R. J. Osborn, new Manufacturing Manager, announced the appointments.



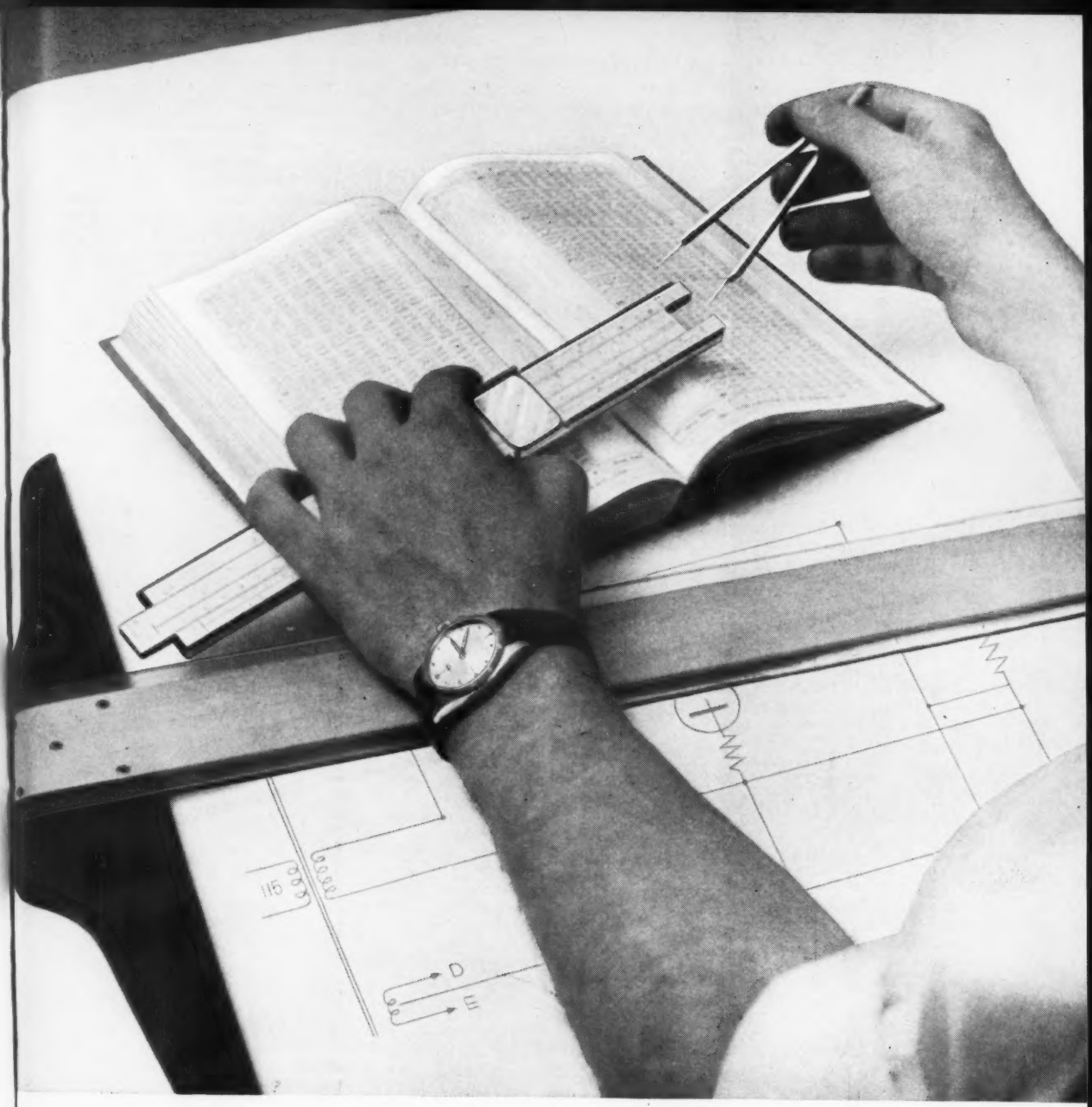
Loewy-Hydropress Division of Baldwin-Lima-Hamilton Corporation has announced that the giant horizontal extrusion press *(above)*—with a squeezing power of 12,000 tons—is in full operation as the only press in the U.S. Air Force Heavy Press Program for the extrusion of steels and large titanium components. A 50-ft.-long tube, 6 in. in diameter *(inset)*, is extruded in 9 sec.

• **Loewy-Hydropress Division, Baldwin-Lima-Hamilton Corporation,** announces that the only press in the USAF Heavy Press Program for the extrusion of steels and large titanium components is in full operation. Operated by the Metals Processing Division of Curtiss-Wright in Buffalo, the giant horizontal extrusion press has a squeezing power of 12,000 tons. The 126-ft.-long hydraulic press was designed, built, and installed by the Division, also builders of the largest forging press for the Air Force. A 50-ft.-long tube, 6 in. in diameter, can be extruded in 9 sec. A thousand feet of half-inch spring steel rod can be extruded in 3 sec. Through its controlled range of speeds and pressures, this giant press can produce critical aircraft components of titanium and stainless steel sections. . . . The Division announces the appointment of Frederick A. Fielder as General Sales Manager.

• **The Glenn L. Martin Company** announces a Vanguard Satellite Essay Contest with prizes and awards totaling $24,000. Martin, prime contractor and designer of the launching vehicle which will attempt to place the earth satellite in orbit during the International Geophysical Year (July 1, 1957, to December 31, 1958), is offering ten prizes totaling $12,000, plus duplicate awards to the accredited institutions sponsoring winning papers. Eligibility to enter the contest is confined to seniors and graduate students majoring in engineering or the sciences at participating educational institutions. Contestants may use any approach, as long as their thoughts bear on some problem associated with the design, manufacture, or use of orbital vehicles. Equally acceptable are papers illuminating nontechnical aspects of satellite vehicles. Entries will be judged for the originality and technical worth of the contribution and for clarity of presentation. All essays are due at the contestant's school on or before March 1, 1957.

• **McDonnell Aircraft Corporation . . .** J. S. McDonnell, President, has announced the appointment of William B. Haylon as Manager of Public Relations, effective November 1. Mr. Haylon formerly was with the General Electric Company where he served 21 years, most recently as Manager of the Press Relations Service, with headquarters in the New York Executive Offices, and as a member of the Planning Board of the Public Relations Division.

• **Meletron Corporation . . .** George A. Starbird, President, has appointed William G. Mays Director of Sales and Service.



What's most important in this picture?

Not the slide rule, though it's helpful. Nor the divider. Nor the logarithm table. It's the human hand, of course, because it is motivated by the long, strong arm of human intelligence. It belongs to the career engineer dedicated in his service to the Department of Defense.

His mind and his hand shorten the coupling between a need urgently expressed by the military and its translation by industry into reliable electronic equipment. His experience contributes invaluable help at a critical stage in developing great new things in aviation electronics.

LMEE

In Aviation Electronics Products Include . . .

FIRE CONTROL RADAR • SEARCH RADAR • INDICATORS AND DISPLAY • COUNTERMEASURES • NAVIGATION
MISSILE CONTROL • AIRBORNE SONAR • COMMUNICATIONS • FUZES • AUTOMATIC TEST • DATA PROCESSING

At LMEE . . . as everywhere in General Electric . . .

Progress Is Our Most Important Product

GENERAL ELECTRIC

LIGHT MILITARY ELECTRONIC EQUIPMENT
FRENCH ROAD, UTICA, NEW YORK

Designed for weapon system evaluation and training in the Mach 0.9 class at 50,000 ft., Radioplane's RP-70 type rocket-powered drone is the newest in the company's series of target aircraft.

• **Minneapolis-Honeywell Regulator Company** . . . W. W. Gilmore, President of the Micro Switch Division, has been elected a Vice-President of the company. . . . The first guidance reference system for the dozen or more proposed earth-satellite-carrying rockets has come off a pilot production line in Minneapolis more than a year before the Project Vanguard vehicle is scheduled to be launched. Honeywell's Aeronautical and Ordnance Divisions are building the inertial guidance-type systems for the rocket's prime contractor, The Glenn L. Martin Company. . . . Major contractors for a new $4 million inertial guidance manufacturing plant for the Aeronautical Division to be constructed near St. Petersburg, Fla., have been named by Melvin P. Fedders, Division Vice-President and Manager for the new plant. Target date for the plant's opening is February, 1957. Honeywell will need more than 1,500 engineers and production workers soon after opening in order to be in full production by July 1, 1957. . . . A weight-savings of nearly 50 per cent is a feature of a new internally mounted tank unit for use in fuel quantity measuring systems for aircraft, according to the Division. The unit (labeled the FG250A) consists of two concentric tubes which form the capacitor, integral compensator, spacers, insulators, and provisions for bulkhead mounting and electrical connections. Unit lengths vary from a minimum of 5.2 to 100 in. Weight-savings were achieved by uses of plastic and coated aluminum parts. . . . Precise control of jet aircraft inlet air diffusers at flight speeds of Mach 1.4 and higher is discussed nontechnically in a new 8-page booklet published by the Aeronautical Division. Describing studies in the field, the booklet is believed to be the first of its kind made available to the aircraft in dustry.

• **Norden-Ketay Corporation** has leased a building on Commerce Road in Stamford, Conn., according to an announcement by Perry R. Roehm, President. The new building will be used for executive offices presently located at 99 Park Ave., New York, and to establish a central research laboratory for missile work. . . . The corporation reports its Type T231 Automatic Electronic Photo Printer utilizes revolutionary electronic control in "dodging" negatives during printing. Negatives considered unprintable can now produce useful results since blocked shadows and chalky highlights are absent. So exact is the exposure control, Norden-Ketay says, that prints made by this method may be processed at high speed while still in roll form—eliminating the necessity for remakes. Further information can be obtained from the corporation at its New York office.

• **Northrop Aircraft, Inc.** . . . Robert R. Miller (AM), who joined Northrop in 1951 and was named Vice-President and General Manager last May, has been elected to the Board of Directors. He also is a Director of the Radioplane Company, a Northrop subsidiary. . . . The company's guided-missile program has necessitated leasing of an additional 72,000-sq.ft. administrative facility in Torrance, Calif. Northrop currently employs about 20,000 personnel at several locations throughout the nation. Main base of operations is its Hawthorne, Calif., plant where about 15,000 are employed. . . . Northrop scientists have duplicated the balance mechanism of the human inner ear in perfecting a highly effective "brain" unit for use in its advanced guided-missile programs. The small instrument, weighing slightly over an ounce, is made of glass tubing and even resembles the convolutions of the inner ear in shape. . . . Plug-in circuit boards which reduce wiring costs substantially have been developed by the corporation. Malfunctioning or worn switches need not be disconnected, reconnected, and then resoldered when the new concept is used. The device utilizes twelve printed circuit boards which can be plugged into mating printed circuit connectors. It is used in ground support and field test equipment for the USAF Northrop SM-62 Snark intercontinental missile program and is adaptable to electronic computer equipment.

• **Pacific Scientific Aeroproducts** has completed plans for a new plant and office building to be constructed on a 10-acre site recently purchased in Anaheim, Calif. About 50,000 sq.ft. of space will house the company's manufacturing facility, engineering department, business offices, and a specially designed, dust-free instrument assembly area. A study established that the company's present buildings, expanded several times since it was founded in 1938, could not handle current growth adequately. The announcement was made by Leo A. Pfankuch, Executive Vice-President.

• **Pan American World Airways** has announced that it has cut its transatlantic fares 40 per cent for European immigrants during the period November 1 through March 31. The new fares have been approved by the CAB and by other governments concerned. One-way fares to New York under the new rates will be $197 from Frankfurt; $211 from Vienna; $186 from Paris, Amsterdam, or Brussels; $197 from Copenhagen; $213 from Stockholm; and $178 from Lisbon. . . . Leonard P. Cornwall, who joined the company in 1946, has been appointed Cargo Sales Manager—United States.

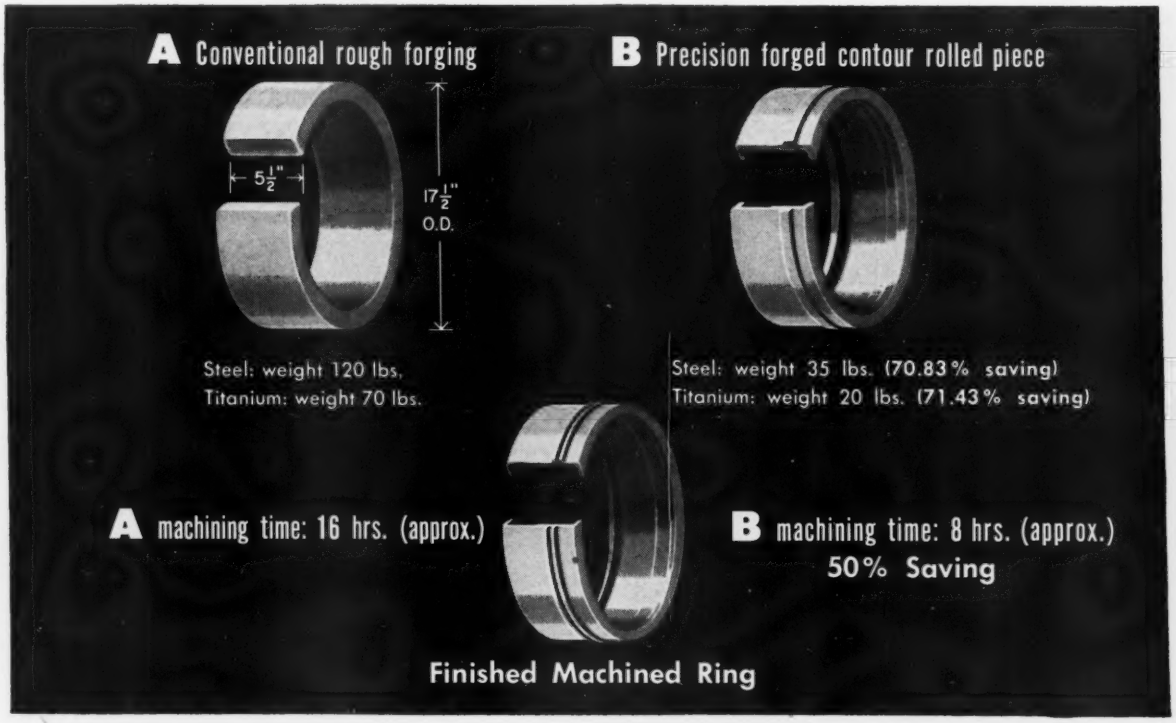
• **The Parker Appliance Company** . . . William G. Webster, who joined Parker as a Test Engineer in 1951, has been appointed Chief Engineer for the Cleveland Division of Parker Aircraft Company, Los Angeles. He succeeds Wilton Margrave, who has been transferred to Los Angeles to direct hydraulic engineering activities for Parker Aircraft.

• **Radioplane Company** has announced development of a new rocket-powered target drone series designated the RP-70 type. Designed for weapon system evaluation and training in the Mach 0.9 class at 50,000 ft., the RP-70 is powered by a solid-propellant rocket with a flight endurance of 8 to 10 min. The air frame, weighing 300 lbs., is designed specifically for high volume production. It is slightly over 9 ft. long, with a wing span of 5 ft. With the exception of the steel rocket motor case, which makes up the mid-section of the fuselage, all other primary structures are made of glass fiber, reinforced plastic. The plastic wings and horizontal and vertical stabilizers are fixed surfaces. Control is accomplished by small canard-type vanes located just forward of the wing and linked directly to the flight control system. Pay-load capabilities are sufficient to accommodate the special tracking and scoring equipment required by the Armed Services in training, evaluation, and development of tactics for their various defense missile systems.

• **Reaction Motors, Inc.** . . . The flight-test phase of Project Vanguard will make use of a modified Viking sounding rocket propelled by a rocket engine developed and produced by RMI; the power plant will be of the liquid-propellant type, producing a rated thrust of 20,000 lbs. . . . The appointments of Richard P. Frazee as Washington Office Manager, George T. Correll as Manager of Contracts, and J. Donald Haas as Applications Engineer in the Washington Office have been announced by Warren P. Turner, RMI's Director of Applications Engineering and Contracts.

• **Republic Aviation Corporation** and the University of Maryland have announced first flight of a new, extremely lightweight,

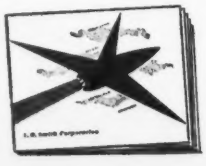
The difference in these processes could be worth millions *to your company*


A Conventional rough forging
B Precision forged contour rolled piece
5½"
17½" O.D.
Steel: weight 120 lbs.
Titanium: weight 70 lbs.
Steel: weight 35 lbs. (70.83% saving)
Titanium: weight 20 lbs. (71.43% saving)
A machining time: 16 hrs. (approx.)
B machining time: 8 hrs. (approx.)
50% Saving
Finished Machined Ring

The difference is E.D.O.S.

Engineered Designs for Optimum Structures

FROM the example above it is evident that material costs *alone*, using conventional methods, can exceed the total finished cost of parts produced by the exclusive A. O. Smith E.D.O.S. process. By comparing a conventional rough forging with a precision-forged, contour-rolled ring (A and B illustrated above), material cost of the finished ring is cut by more than *70%* — machining time cut by 50%! These great savings — due to conservation of costly metal by predetermined distribution — are possible with steel, titanium and other heat-resistant alloys. The whole E.D.O.S. process (involving precision forging, contour rolling, flash and fusion welding) can build a lighter, stronger product faster and at lower cost than any other existing method! For further information about E.D.O.S., contact A. O. Smith Corporation, Milwaukee 1, Wisconsin.



WRITE TODAY FOR FREE ILLUSTRATED BOOKLET — Bulletin I-17A — Complete with technical details. Also arrange for showing of new 16-mm. sound color movie about this remarkable process.

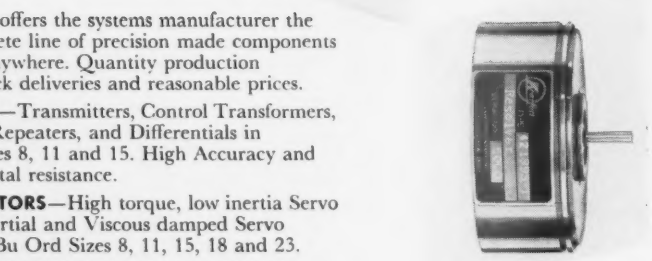
Through research ... *a better way*

A.O.Smith
CORPORATION

MILWAUKEE 1, WISCONSIN
International Division: MILWAUKEE 1, WISCONSIN

Kearfott Components

FOR EVERY SYSTEM APPLICATION



KEARFOTT offers the systems manufacturer the most complete line of precision made components available anywhere. Quantity production enables quick deliveries and reasonable prices.

SYNCHROS—Transmitters, Control Transformers, Resolvers, Repeaters, and Differentials in Bu Ord Sizes 8, 11 and 15. High Accuracy and environmental resistance.

SERVO MOTORS—High torque, low inertia Servo Motors, Inertial and Viscous damped Servo Motors, in Bu Ord Sizes 8, 11, 15, 18 and 23.

TACHOMETER GENERATORS—Available as damping generators, rate generators and integrators. They feature high output to null ratio and extremely linear outputs. Temperature stabilization may be provided.

GYROS—Directional, floated rate integrating, free, vertical, and spring restrained rate gyros for all airborne navigation, stabilization or fire control applications.

Bulletins giving physical and technical data of the various Kearfott Products will be sent on request. The Kearfott organization is available to assist in the development and manufacture of other precision components you may require.

Kearfott

A SUBSIDIARY OF GPE

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.

Sales and Engineering Offices: 1378 Main Avenue, Clifton, N. J.
Midwest Office: 188 W. Randolph Street, Chicago, Ill. South Central Office: 6115 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

high-altitude research missile that raced 3,800 m.p.h. into outer space, obtaining data for use in development of space vehicles. The new rocket is small enough to fit in a family-size station wagon. Its first flight lasted 5.6 min., during which time it ascended to 80 miles and relayed measurements of primary cosmic radiation, temperatures and spin of the rocket, and acceleration experienced by internal equipment. It has been named Terrapin. Two stages take its 224-lb. weight aloft. The first firing was from the NACA proving ground at Wallops Island, Va. Republic's Guided Missiles Division in Mineola, L.I., designed and produced it. . . . Mundy I. Peale, President, has announced the appointment of Robert L. Bortner as Chief Engineer for Administration. . . . The corporation has received a special award from Liberty Mutual Insurance Company for setting an air-frame industry safety record of 5,917,415 man-hours of work without an accident.

• **Shell Oil Company . . .** Edwin D. Maxfield has been named to the newly created post of Commercial Division Manager of the Aviation Department of the company's head office in New York, according to J. S. Harris, Department Manager. Mr. Maxfield will coordinate Shell's sales to air lines, aviation manufacturers, and airports. Previously, he was Senior Representative in the Commercial Division.

• **Thompson Products, Inc. . . .** A 1,000-acre site near Roanoke, Va., has been selected for construction of a new $10 million test facility for the Accessories Division. The new engineering and development center, to be used for testing fuel systems and auxiliary power systems for rockets and missiles, is scheduled for gradual construction over a 5-year period, according to Group Vice-President E. P. Riley and Division Manager P. T. Angell. Said Mr. Angell: "This will be an independent research and development center where the Accessories Division will carry out programs now in progress and planned in these fields of vital importance to the development of systems to be incorporated in the missiles and aircraft of tomorrow." The project will consist of some 14 buildings, including test cell structures, about 4 miles north of Rocky Mount and 17 miles south of Roanoke. Employment will consist of scientific, engineering, and technical personnel, amounting to less than 100 when initial operations get under way in 1957 and increasing gradually to about 500 in 1961.

• **Union Carbide and Carbon Corporation . . .** The corporation's new multimillion dollar research laboratories at Parma, Ohio, managed by its division, National Carbon Company, was dedicated at ceremonies on September 18. Robert G. Breckenridge, Director of the laboratories, took advantage of the occasion to announce that N.C. scientists had discovered how to "weld" pieces of graphite together, providing a new technique which he said promises advances in processing materials for the atomic age. Dr. Breckenridge also reported that the largest single crystals of cadmium sulfide ever reported had been "grown" in the new laboratories. A highlight of the day-long event was a symposium on refractory hard metals. Dr.

NEW from EEMCO

A 400 Cycle AC Linear Actuator

with an operating range of

320 to 480 cycles

SPECIFICATIONS FOR TYPE D-818

Normal operating load: 6000 pounds
Maximum operating load: 12,000 pounds
Ultimate static load: 24,000 pounds
Stroke: 3.15 inches
Rate of travel: .33 inches per second
Amperes: 3 amps. at 480 cycles on 200 volts at the 6000 lb. load
Weight: 20.5 pounds
Qualification: Type D-818 has been designed and qualified to meet applicable military and aircraft manufacturers' specifications.

EEMCO 400 cycle linear actuator **Type D-818** is being installed as a leading edge flap actuator in the latest and fastest supersonic fighter aircraft now being produced for the U. S. Air Force.

Incorporated in the **EEMCO** motor in **Type D-818** is a torque-limiting AC clutch which disconnects the high inertial load imposed by the motor's armature. A brake can be built into this mechanism if **Type D-818** is altered for use in another capacity. Adjustable non-jamming stops are included which are especially convenient when the airplane is being rigged.

One of its outstanding features is that it operates on a frequency range of 320 to 480 cycles, versus a normal range of 380 to 420 cycles. This eliminates need for a constant speed drive for the airplane's generator system, thereby saving maintenance of same as well as considerable cost and weight.

EEMCO is a specialist in the design and production of precision-built actuators and motors. The majority of the latest and fastest aircraft and missiles being produced for the U. S. Department of Defense carry one or more **EEMCO** systems. Industry, too, is using **EEMCO** linear and rotary actuators where precise control of mechanical actuating systems is imperative.

Electrical Engineering and Manufacturing Corp.

4612 West Jefferson Boulevard
Los Angeles 16, California
Telephone REpublic 3-0151

Designers and producers of motors, linear and rotary actuators . . . exclusively!

3-844

Breckenridge was chairman, and speakers included three university professors. The new laboratories contain about 175,000 sq. ft. of floor space and are located near the center of a 126-acre plot. Parma is a suburb of Cleveland. Designed for extreme flexibility, with provision for expansion, the main laboratory building consists of 158 laboratory modules or individual research units. About 350 employees, including 150 scientific and technical personnel, are at work here. The new lab brings to seven the number of major research centers operated by divisions of the corporation. It will concentrate to a large extent on basic research in chemical physics and solid-state physics. . . . Promotions for four of its personnel have been announced by National Carbon. R. L. Westlake has been named Manager of the Central Division of the Carbon Products Sales Department. J. W. Scales has been named Manager of the Mid-Eastern Division of the same department. William C. McCosh has been appointed Manager of Railroad and Industrial Brush Sales. A. W. Wolff has been named Manager of Carbon Specialty Sales. . . . Haynes Stellite Company, a division of UCC, has been licensed to produce and sell GMR-235 after 5 years of cooperative research and development work with the Research Laboratories Division of General Motors Corporation. GMR-235 is a nickel-base, high-temperature alloy containing chromium, molybdenum, iron, and boron, with aluminum and titanium as precipitation-hardening agents. Produced both by air-melting and vacuum-melting techniques, it was designed for investment-cast turbine wheels, buckets, and vanes for use at temperatures in excess of 1,400°F.

• **United Air Lines, Inc.** . . . New streamlined propeller spinners which add 3 m.p.h. to the present 365 m.p.h. cruising speed of DC-7's are being installed on all United aircraft of that type. In addition, the aluminum spinners insulate propeller oil against congealment in winter and improve the flow of air to engine cylinders—the latter an important consideration during full power take-off. All United's "Sevens"

The high-altitude chamber in Union Carbide's new research laboratory, managed by its National Carbon Division, is pictured above. Conditions can be varied from sea level pressure down to 1/1,000 of that value, temperatures from −85°F. to 200°F. Humidity also can be varied within wide limits.

are expected to be so equipped by the end of the year.

• **United Aircraft Corporation** . . . John F. Burridge has been named an Assistant Sales Manager of Hamilton Standard Division in one of a series of sales department changes announced by Erle Martin, General Manager. Alfred B. Thacher has been promoted to Mr. Burridge's former post, Dayton Representative of United Aircraft Service Corporation. Morgan Jones has been promoted to Mr. Thacher's former position as Chief Sales Engineer for Propellers. . . . The Division opened a New York recruiting center on October 14 in the Governor Clinton Hotel, opposite Pennsylvania Station. It will interview engineers in the fields of design, metallurgy, analysis, development, vibration, and drafting and checking. . . . The Division has purchased a permanent site for its Florida engineering operation. Totaling about 290 acres, the site is at Starkey and Bryan Dairy Roads in Pinellas County on the outskirts of St. Petersburg. . . . Three have been promoted in the Sales Engineering Section. They are Bruce Lockwood, Robert R. Hunt, and Raymond B. Carroll—all named Senior Sales Engineer.

• **Vickers Incorporated** . . . A compact, lightweight pressure control block for airborne oil-hydraulic systems is available. Designated Series EA-52008-A1, the new unit consists of a flow-sensitive pressure regulator valve, a system relief valve and a check valve, all combined within a single housing. It has been qualified to use at temperatures from −65° to +275°F. Recommended nominal operating pressure is 3,000 psi. It is designed to permit mounting in any position, and all connections conform to Specification AND 10050-8. . . . A new 4-page illustrated two-color bulletin (*A5212*) describing the recently announced Vickers air-borne in-line relief valves is available from the company, Box 302, Detroit 32, Mich.

• **Westinghouse Electric Corporation** has developed a lightweight, mobile radar of revolutionary design and long range for the Air Force. Key development, the company reports, is the antenna. Two paraboloids—one coated inside with vaporized aluminum to form the radar reflector—are joined at their rims and inflated. Called the Paraballoon antenna, this radar was developed to detect high-flying aircraft.

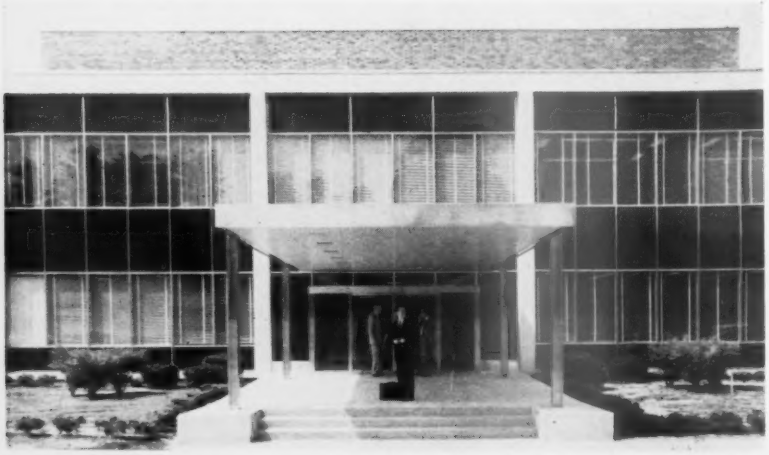
An air-supported radome, lightweight, sectionalized, and designed to erect on the ground, protects the radar and electronic equipment, operating personnel, and the Paraballoon antenna from high winds and ice loads. Within the radome, the Paraballoon antenna is supported in an upright position on a collapsible magnesium base by a difference in air pressure. Thus, the corporation said, a compact and complete radar structural system is obtained which literally is "blown up like a balloon."

The radome can be deflated and unzipped into sections and the associated supporting structures collapsed. As a result, the entire antenna system can be dismantled in a matter of minutes and packed in shipping containers of small volume. Fully packed containers weigh about 200 lbs. each and can be handled easily by two or three men.

The Paraballoon antenna can be erected and dismantled an unlimited number of times. It retains its desired reflector contour when inflated—even after repeated rough handling—and no special fixtures are required for checking the reflector surface contour when the inflated antenna is erected. Air drops of an entire radar set are feasible.

The antenna is made from a vinyl-coated fiberglass fabric—fiberglass fabric being chosen because of its high modulus of elasticity and consequent low stretch. To form the assembled antenna, two paraboloids of revolution 30 ft. in diameter are joined at their rims and inflated to less than 0.02 psi above the surrounding pressure. When inflated, the two paraboloids are stabilized by a 16-in.-diameter fabric tube that is incorporated into the rim of the antenna and inflated to 10 psi. Inflated, the Paraballoon antenna system is 30 ft. high and weighs only 1,690 lbs.

The modern entrance to the new research laboratories of National Carbon Company, a Division of Union Carbide and Carbon Corporation. It contains about 175,000 sq.ft. of floor space in suburban Cleveland.



F-104 STARFIGHTER—WORLD'S FASTEST JET FIGHTER— AMAZES VETERAN PILOTS WITH ITS PRECISE CONTROLLABILITY

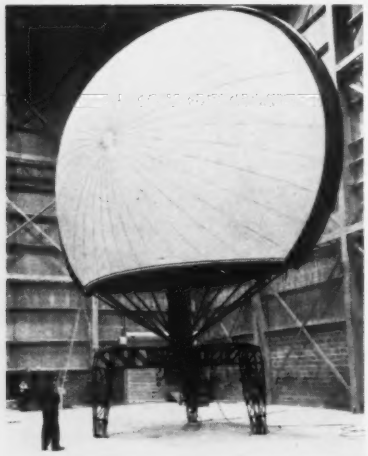
Originally developed for the U.S. Air Force as a day/night air superiority fighter, the Lockheed F-104 *Starfighter* is about to become operational with the Air Defense Command—and soon thereafter with the Tactical Air Command.

An exciting aircraft to fly, the F-104 flashes through the sound-barrier routinely, without a tremor—and possesses a responsiveness and stability unmatched by many planes of less spectacular speed.

In ease-of-maintenance, too, the F-104 is outstanding. Its unique basic design incorporates many advanced features that reduce on-the-ground time and costs—thus adding extra hours of vital flying time for the *Starfighter* to defend our nation against attack by any aggressor.

Look to Lockheed for Jet Leadership, too

LOCKHEED Aircraft Corporation, Burbank, California



This is the new Westinghouse Paraballoon antenna radar developed by Westinghouse Electric Corporation, which has been called a major break-through in the design of ground electronics equipment.

The radome is designed so that temperatures ranging from −65° to +140°F. and wind velocities of 125 m.p.h. will not cause interference with antenna rotation. Air pressure inside the antenna is maintained greater than air pressure inside the radome by a fixed amount. Entrance to the radome is through a pressure-lock door. Air pressure inside the radome—about 0.17 psi above atmosphere—is not uncomfortable to personnel.

Ground anchors secure the radome, which is sectionalized into five side panels and one crown piece for ease in transport and erection. Total radome weight is about 1,400 lbs. Blowers are used for both the antenna and radome housing. Wide variations in the amount of air leakage from either inflated area will not result in large pressure changes. This, coupled with rip-resistant fabric, makes the complete system insensitive to minor tears. More than 50 20-mm. projectiles can pierce both antenna and radome without affecting normal operation.

Fifty-ft. Paraballoon antennas are being manufactured now for the USAF and Marine Corps by Westinghouse.

• **Young Radiator Company** announces two new Vertiflow vertical-flow Unit Heaters, one exceeding 1,000,000 B.t.u./hour output, which are designed especially to heat airplane hangars and industrial buildings having extremely high ceilings difficult to heat because of air stratification.

Three types of air diffuser are available—a Revolving Diffuser which turns the full 360° fitted with adjustable vanes to vary the diameter of the air spread, an Aero-Jet II Nozzle for extreme mounting heights and high velocity air, and the Conventional Spreadaire Diffuser adjustable to a 45° angle.

Such units and accessories are illustrated in a new 6-page *Catalog No. 2856*, which includes capacity tables, dimensional drawings, and all necessary engineering information. It will be mailed on request.

IAS SECTIONS

Atlanta Section

Ninety-one members and guests of the Atlanta Section met for dinner at the Officers Club, Atlanta NAS, on October 4.

A plaque was presented to Lt. Comdr. Joseph Coleman as an expression of appreciation for his courtesy as a guide for the Atlanta Section Field Trip to the U.S. NATC Headquarters and Base at Pensacola, Fla.

Retiring Chairman Arnold L. Ducoffe installed newly elected officers, who are Waldon R. Rhoads, Chairman; C. F. Friend, Vice-Chairman; C. V. Williams, Secretary; and R. S. Chubb, Treasurer.

Program Chairman R. F. Stoessel introduced Thomas J. Harris, AMIAS, Director of Cargo Sales for American Airlines, Inc. Mr. Harris spoke on "Air Cargo," beginning with a review of the post World War II prognostication that air cargo transportation would, within a few years, account for the major part of the activity of the air transportation industry—a forecast which was inaccurate. (A current reassessment of air cargo potential has been made and when extrapolated to 1965 indicates a growth to a billion ton-miles per year for the industry.)

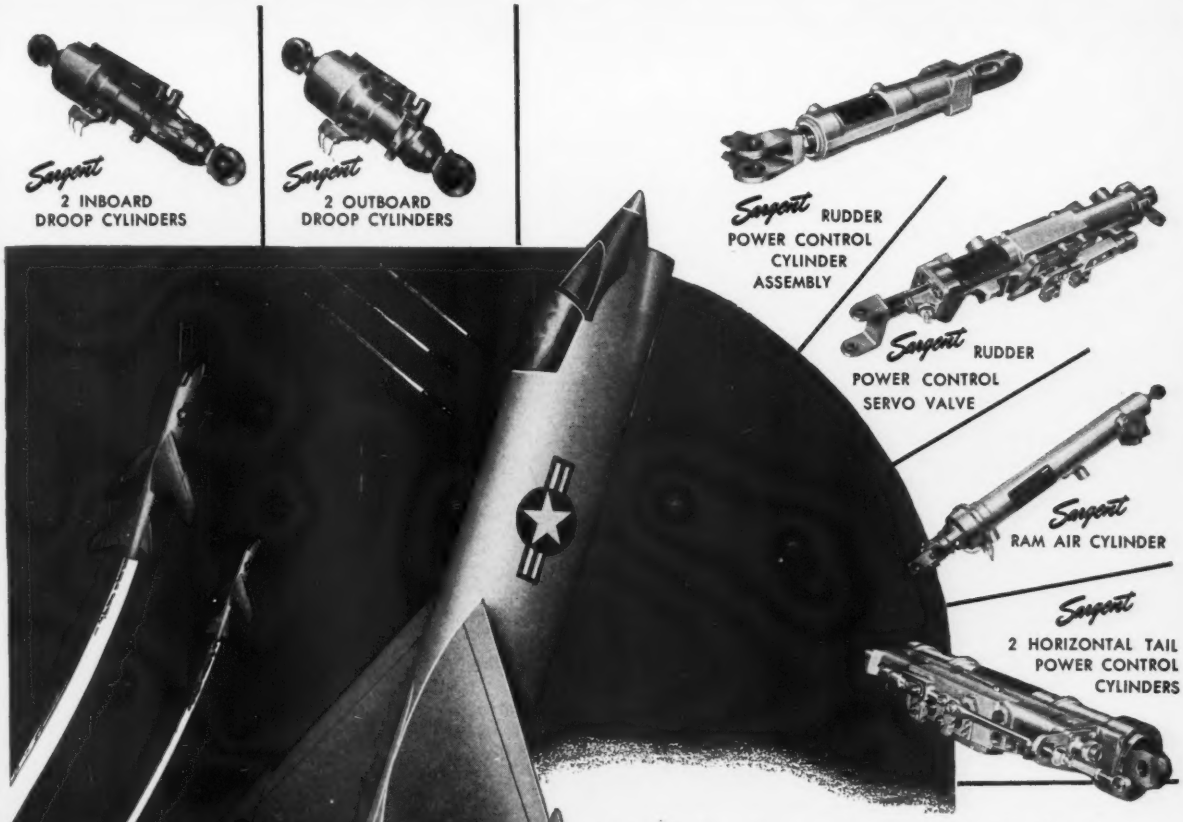
It was emphasized by Mr. Harris that he believes the figure is low if certain goals can be reached. He said he thinks that an immediate increase in air cargo sales can be accomplished by analyzing carefully the prospective customer's transportation and storage system and, from the findings, showing the customer how reduced overall costs and increased profits can result from air transportation use.

Mr. Harris suggested that the sales campaign stress three important advantages of air transportation—packaging and security, methodology, and speed—and that the analysis show the customer how his product can be packaged to reduce costs and, in addition, how the shorter elapsed time and reduced handling mean less chance of breakage and pilferage—resulting in lower insurance costs.

Another source of savings, Mr. Harris said, is in the methodology of rate classification that is considerably simpler for air shipments than for surface transportation. This simplicity, he declared, can effect savings in the number of personnel and time required to process a shipment through the traffic department of the potential customer and hence reduce his overall shipping costs.

Mr. Harris warned that the speed factor in the sales presentation should be considered carefully since speed is not essential for some industries. He added, however, that it can be shown readily that, for many manufacturers of products which are seasonal in nature or have style as a consideration, speed of delivery can result in better customer service and accomplish increased overall sales.

IAS President Edward R. Sharp chats informally during the Atlanta Section's Annual President's Night on September 6. Pictured *left to right* are F. N. Dickerman, Chief Preliminary Design Engineer, Lockheed Aircraft Corporation, Georgia Division; C. E. Woolman, President, Delta Airlines; Edith H. Lively, Section Treasurer; Dr. Sharp; and Gordon P. Thorn, Assistant Chief Engineer of Lockheed's Georgia Division. Miss Lively also is with Lockheed, in Sales Engineering.


Sargent
2 INBOARD DROOP CYLINDERS
Sargent
2 OUTBOARD DROOP CYLINDERS
Sargent RUDDER POWER CONTROL CYLINDER ASSEMBLY
Sargent RUDDER POWER CONTROL SERVO VALVE
Sargent RAM AIR CYLINDER
Sargent 2 HORIZONTAL TAIL POWER CONTROL CYLINDERS

World's Fastest Navy Fighter

9 Proudly wears Sargent controls

Nine Sargent quality units have been selected to provide Chance Vought's F8U-1 Crusader with instantaneous, positive, feathertouch response.

These units, Sargent fabricated to Vought specifications, provide a system for control for the safe, positive, efficient operation of this great fighter.

The experience of more than 36 years of design and manufacture of precision equipment systems has given Sargent Engineering Corporation the "know-how" to aid in solving the essential and advance problems of force control. Leading airframe and missile manufacturers are using hundreds of different Sargent hydraulic, mechanical, pneumatic, electrical and electronic force control units on the nation's military planes, commercial planes and missiles.

Sargent places its facilities of design and manufacture at your disposal. We invite you to send your specifications for the Sargent proposal of your force control problems.

ndard
D WILL"
pleased
urn
the place
as been
ell treated.
— Supreme Court

Sargent

Since 1920

ENGINEERING CORPORATION

2533 EAST 56th STREET
HUNTINGTON PARK, CALIFORNIA

BUILDS QUALITY THAT BUILDS GOOD WILL

All 30 members of the Chicago Section who recently saw the U.S.S. "Saipan" in action are pictured on the aircraft carrier's flight deck.

At this point, Mr. Harris indicated that proper accounting techniques must be followed to account for manufacturing and fixed costs so that, in truth, increased sales do bring in profits that more than offset the added cost of air rather than surface transportation.

Mr. Harris concluded with a discussion of inventory systems, pointing out that speed of delivery can be an important factor in reducing inventory and storage costs. He cautioned, however, that each prospective market should be studied carefully with attention to all factors involved in the value of speed.

C. V. WILLIAMS, *Secretary*

Chicago Section

The Section's 1956–1957 program got under way on October 3 as Chairman Lee Sims introduced Col. Harry G. Spillinger, USAF, an Associate Fellow and a founder of the IAS, to about 60 members and guests. Colonel Spillinger, Chief—Production Engineering Staff, Office of Director of Procurement and Production, Air Material Command, spoke on "Reliability of Air Force Equipment," stressing the positive approach of the USAF in maintaining high reliability for defensive and offensive equipment.

Colonel Spillinger, using a fighter-interceptor mission as an example, pointed out how larger areas must be covered in the modern concept of war under all types of weather, day and night. Such conditions, he said, require a higher degree of efficiency than a pilot can deliver, and electronic sensing devices must be developed to supplement pilot reactions. He also warned that a high degree of reliability must be maintained in ground radar, aircraft navigation, and air-borne radar equipment because of little likelihood that fighter-interceptors will be given a second chance at their target.

In order to help the probability of failure approach zero, Colonel Spillinger said, industry should lean further toward common-sense engineering, quality control, and 100 per cent inspection of all components. A question and answer period followed his talk.

On September 11, 30 members of the Section left Glenview Naval Air Station aboard an R5D for what doubtless will remain in the minds of all as a highlight of the Section year—a tour of Pensacola NAS and sea duty aboard the U.S.S. "Saipan."

Arriving at Pensacola at 2:30 p.m., the group inspected the base, seeing fire-fighting, water survival, and air-sea rescue demonstrations and an air show. It was early to bed on the 11th and early to rise on the 12th. Section members "hit the deck" at 5:30 a.m. in order to board the Saipan for a 7:00 a.m. departure. The day included a tour of the ship, plus lectures and films explaining functions of the divisions, with emphasis on flight deck operations.

Members were invited to the bridge to observe from the best vantage point possible how carrier landings and take-offs are made. The first demonstration was put on by flight instructors, with the balance of flights being made by cadets attempting to qualify. Also on the program was a ship-to-ship transfer of personnel via breeches buoy.

The Saipan returned to base at about 4:00 p.m. Later, dinner was served at the Officers Club, where a talk was given by Capt. A. E. Loomis, USN, Chief of Naval Air Basic Training. The Naval Cadet Choir provided an enjoyable evening's entertainment.

On the morning of the 13th, the group was taken on a tour of Forts Barrancas and San Carlos, two of the oldest fortifications in the nation. That afternoon, at 3:30, members were back at Glenview NAS.

R. F. HUNTER, *Secretary*

Cleveland-Akron Section

The 1956–1957 season was given a successful send-off on September 18 at the Manger Hotel, Cleveland, as Harry Hjorth, Assistant Project Engineer on the Douglas DC-8 turbojet transport, presented an interesting and timely talk on the jet giant. He spoke before about 150 engineers representing the numerous companies and groups associated with the aircraft industry in the Cleveland-Akron area.

Mr. Hjorth reviewed the general design philosophy of the airplane and described many of the operating details, novel design features, and safety aspects. From the standpoint of operation, emphasis was placed on both the long- and short-range economy of the 265,000-lb. transport. This operating efficiency, when combined with the flexibility of interior arrangement that leads to rapid conversion between coach and first-class accommodations, provides for maximum air-line utilization and economy, Mr. Hjorth said.

The speaker said safety was a keynote in the DC-8's design. Of many safety design features, one of the most striking is how fuselage structure is so arranged as to contain skin rips in extremely small areas—thus avoiding catastrophic failure such as those which occurred in the Comets.

WILLIAM A. FLEMING, *Treasurer*

Columbus Section

A record turnout of 93 guests and members attended the first meeting of the 1956–1957 season on September 19. Feature of the meeting was a talk on new aircraft introduction to fleet operations by H. M. Schaeffer, Manager, Field Service Department, Columbus Division, North American Aviation, Inc.

The magnitude of the effort required to introduce new aircraft into current fleet operations was illustrated vividly by the speaker when he compared an 18-page handbook prepared in 1918 by Curtiss-Wright for the "Jenny" with the better-than-3,000 pages of printed matter issued on the FJ-4, now going into fleet operation. Using charts, Mr. Schaeffer showed that the task of introducing new aircraft to the fleet consists of four basic problems:

(1) The airplane must be capable of fulfilling the mission for which it has been designed.

(2) The costs of procurement of such aircraft and supporting components must be closely controlled.

(3) Adequate provisions must be made for the logistic support of the aircraft.

(4) Increasing attention must be paid to the low-experience personnel available to the Services for maintenance of such aircraft.

Capital Airlines' new fleet of Vickers Viscounts cruise at 335 mph. So quietly and smoothly, you can balance a quarter on edge. They are powered by the new Rolls-Royce "Dart" turboprop engine. Nickel...in alloyed materials... accounts for 6% of this engine's total weight.

Rolls-Royce turboprops depend on nickel-containing alloys

THE ROLLS-ROYCE "DART," a turboprop engine now powering Viscount airliners, has provided the airline passenger with new standards for smooth, quiet air travel. Most notable is the reduction of noise and vibration.

Internal heat was a major problem to the Rolls-Royce engineers who designed this engine. As in jet engines, operating conditions in the Dart require high strength in vital parts despite intense heat... as well as exceptional resistance to high-temperature corrosion and oxidation.

Accordingly, the designers turned to nickel-alloyed materials for the desired properties in turbine blades, combustion liners and other key parts. Alloys used in the Dart are tabulated here because they may offer advantages to you. Whatever your metal difficulties, let us help you with our wide practical experience. Send details of your problem, for our suggestions.

Part	Material
Compressor Assembly	
Impeller Shaft	2% Ni-Cr-Mo case-hardened steel
Rotating Guide Vanes	4% Ni austenitic steel
Combustion System	
Nozzle Guide Vanes	12% Ni–23% Cr–3% W austenitic steel
Combustion Chamber	Cast 60% Ni-Cr alloy
Flame Tubes, and Nozzle Box (Gas temperatures to 1560°F.)	"Nimonic* 75," 76% Ni–20% Cr alloy
Fuel Burners	Type 310 (25% Ni–20% Cr) stainless steel
Turbine Assembly	
1st Stage Rotor Disc	13% Ni–13% Cr–10% Co austenitic alloy
1st Stage, 131 Rotor Blades	"Nimonic* 80A," 76% Ni–20% Cr alloy
2nd Stage, 103 Rotor Blades	"Nimonic* 80A," 76% Ni–20% Cr alloy
All Stator Blades	12% Ni–23% Cr–3% W austenitic alloy
Exhaust Unit	
Exhaust Casing	18% Cr–8% Ni+Ti, Type 321 stainless
Tail Cone	"Nimonic* 75," 76% Ni–20% Cr.
Reduction Gears	2% Ni alloy heat-treated steel
Rotor Shaft	19% Cr–14% Ni austenitic steel

*Registered trademarks

INCO TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N.Y.

FIGHT VIBRATION WITH VIBRATION

How many jobs can a vibration exciter do?

SHAKER SYSTEMS can help you in *at least* five important ways.

Fatigue testing. Shakers have both the range and capacity to determine fatigue limits of structural members, assemblies, aircraft wing and tail structures. Peak forces of up to 25,000 pounds are now obtainable with MB Exciter Systems.

Environmental vibration testing to MIL-E-5272 and other government specifications. This is most important now for assuring reliability of performance in military production. But the same techniques can be used also to improve *all* types of products.

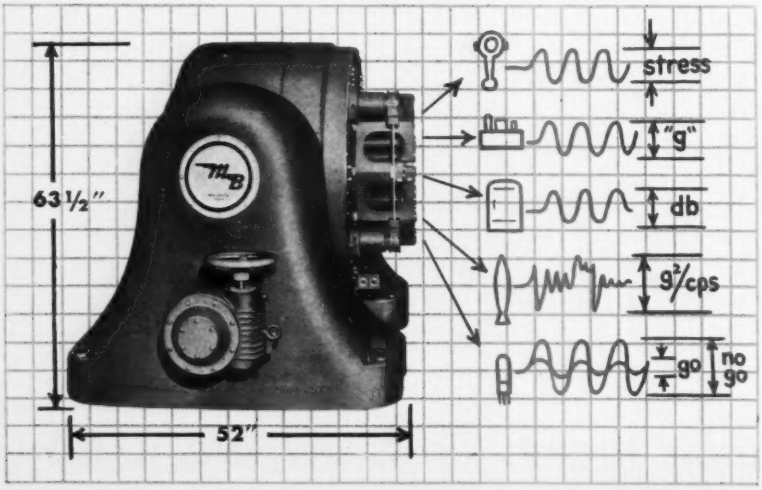
Noise. Just where in a product does it come from and how to eliminate it? An MB shaker helps pinpoint the disturbance by letting you vibrate the product through a whole range of frequencies with the twist of a dial.

Complex wave testing, including random motions. This is something *new!* It subjects a specimen to the same kind of vibration as that encountered in actual service. MB electrodynamic shaker systems offer the frequency range, high acceleration, and freedom from distortion needed for this kind of job.

Production and Quality Control. *Your* ideas are needed here. For example: Someone discovered that size of fine powder particles which sift readily through a screen varies with the screen's frequency of vibration. Permitting easy control of frequency, an MB shaker is capable of working on a *production* line! Tubes too are being production-tested with MB Exciters.

If you need help in putting vibration exciters to work, get in touch with MB . . . leading producer of vibration test equipment.

MB *manufacturing company*
A DIVISION OF TEXTRON INC.
1060 State Street, New Haven 11, Conn.
HEADQUARTERS FOR PRODUCTS TO ISOLATE . . . EXCITE . . . AND MEASURE VIBRATION



The six elements of a broad program being followed by the Navy and Naval contractors to resolve the previously outlined problems in introduction of new aircraft then were reviewed by the speaker. Early in the production program, he said, a total of six airplanes participate in what is known as FIP or the Fleet Introduction Program. FIP amounts to an accelerated test program conducted during an 8-week period at the Naval Air Test Center, Patuxent River, Md. During this period, representatives from Naval operating units conduct simulated operational missions on six aircraft with the objectives of achieving a minimum of 600 flight hours on each. Such a program provides a good indication of the reliability and serviceability of the aircraft and aids in the determination of the number of personnel and parts that will be required to support it in service.

Mr. Schaeffer said that a second policy observed by the Navy in introduction of new aircraft is that of maintaining in production the model of aircraft being replaced. Production of the replaced model is continued until such time as the ultimate success and usefulness of the new air weapon is assured. A third part of the solution to the introduction problem consists of a well-organized logistic support effort on the part of Naval agencies and the factory producing the aircraft. In this latter connection, the Navy is following a policy where fleet operating units can order replacement parts directly from the factory during the first year of operation of aircraft. Preparation and dissemination of handbooks was the fourth part of the solution. Included in the handbook category are the flight handbook for pilots, maintenance handbooks of the various systems and components of the airplane, a parts catalog, and inspection data sheets.

Training of Naval personnel by the contractor represents a fifth part of the solution to the introduction problem. Mr. Schaeffer pointed out that this training begins early during the development stage of the airplane when key Naval test and operating personnel are introduced to the features of the aircraft. During the period when the developed airplane is being introduced to the fleet, the contractor supplies training units and personnel for use in indoctrination of maintenance personnel who actually will service the aircraft during its operational life. This type of training continues on an in-field basis during the entire life of the airplane.

An accelerated overhaul program designed to achieve operational use of an airplane to a greater extent during its early life constitutes the final solution to the introduction problem.

Mr. Schaeffer showed by example

Solvent free

EPON® ADHESIVES

Plastic wing tank, assembled by bonding with Epon Adhesive VI. Made by Admiral Corp., West Chicago, Ill.

permit instant assembly of components

EPON ADHESIVES permit you to assemble bonded parts immediately, because they contain no solvents. Contact pressure alone is required for high strength bonding of metal, plastic, rubber, wood, or glass parts. Glue lines need not be uniform. Air relief drilling and machine finishing of surfaces before bonding is not required.

Epon adhesives have been used successfully in the manufacture of helicopter rotor blades, honeycomb wing sections, jet fuel tanks, radar antennae, structural joints and floor panels. In many cases, Epon adhesives are replacing expensive riveting and welding operations—often with improved structural strength.

Here are three standard formulations for your specific applications:

- **Epon Adhesive VI:** General purpose, high-strength adhesive. Cures at room temperature or slightly above.
- **Epon Adhesive VIII:** High strength, capable of withstanding moderately high service temperatures. Cures in 90 minutes at 200°F.
- **Epon Adhesive 422:** A special formulation in tape form for service at temperatures up to 500°F.

If you have an assembly problem that Epon adhesives may solve, we'll gladly send samples and full technical information. Just write or telephone.

(Epon resins are the epoxy polymers made exclusively by Shell Chemical Corporation.)

SHELL CHEMICAL CORPORATION

CHEMICAL SALES DIVISION, 380 Madison Avenue, New York 17, New York

Atlanta • Boston • Chicago • Cleveland • Detroit • Houston • Los Angeles • Newark • New York • San Francisco • St. Louis

IN CANADA: Chemical Division, Shell Oil Company of Canada, Limited • Montreal • Toronto • Vancouver

SHELL

how the old procedure of overhaul, which extended airplane life to some $7^1/_2$ years, has been revised to compress this same useful service life into a period of $5^2/_3$ years. The program also increases considerably the availability of the airplane during the first $3^1/_2$ years of its use, when it is most modern and up-to-date, as compared to former procedures when substantial periods of time during the first 2 or 3 years were consumed in major overhaul operations.

Mr. Schaeffer closed his talk with a plea for emphasis during the design and development stage for maximum consideration of accessibility, reliability, and simplicity for aircraft component systems.

FREDERICK L. BAGBY, JR.
Secretary

Dayton Section

On September 27, an estimated 200 members and guests enjoyed an interesting tour of the Wright Air Development Center Powerplant and Propeller Laboratories at Wright-Patterson AFB. Dinner was served in the Mural Room, and welcoming remarks were made by Col. H. S. Sewart, USAF, Chief of the Propeller Laboratory.

The tour included an inspection of the Powerplant Laboratory facilities, including the ram-jet and altitude test stands. Members saw a turbojet engine demonstration run in the outdoor test stand, the firing of a liquid and solid-propellant rocket at the rocket test area, a demonstration run of a turboprop engine equipped with a supersonic propeller, a supersonic propeller test, a propeller gyroscopic load test, and a helicopter blade rotating test.

W. E. STANGER, *Secretary*

Indianapolis Section

The first meeting of the 1956–1957 season was held on October 8 at the Marott Hotel. A short business meeting was conducted by Chairman Robert E. Saff. About 160 members and guests heard Howard A. McGlasson, Assistant Project Engineer, Lockheed Aircraft Corporation, speak on the Electra. Jack C. Fetters, Chief Engineer, Power Turbines, Allison Division, General Motors Corporation, an Associate Fellow of the IAS, introduced the speaker.

Mr. McGlasson described some of the design philosophy behind the Electra, using slides for a comparison against existing transport aircraft and an analysis of the best combination of features such as range, stage length, block speeds, cost per mile, etc.

Seating arrangements for custom and coach versions were described. Emphasis is being placed on passenger comfort. Mr. McGlasson's talk indicated that a great amount of time and effort has been spent in order to produce a superlatively efficient aircraft. The air lines will receive the first Electras in the fall of 1958.

P. N. BRIGHT

Los Angeles Section

Welco E. Gasich, Chief of Preliminary Design at Northrop Aircraft, Inc., was installed September 20 as Chairman of the Los Angeles Section. Other new officers for the 1956–1957 season are M. C. Haddon, Vice-Chairman; A. J. Carah, Secretary; and Charles F. Sardou, Jr., Treasurer. Area Counselor is Warren Dickinson.

Mr. Gasich heads the Northrop engineering team that developed the design for Northrop's new USAF supersonic jet trainer.

San Antonio Section

The San Antonio Section held its September meeting at Sevenoaks Country Club on the 15th. About 40 persons, including wives of members and potential members, were present.

Major Gen. Brooke E. Allen, Commander, Military Air Transport Services, Continental Division, was principal speaker, discussing the paper he presented at the Institute's National Turbine-Powered Air Transportation Meeting in San Diego August 15–17. The General reviewed briefly experiences in the conduct of the accelerated test program to prove-out certain turbine-engine and propeller combinations planned for use in operational, turboprop transports in production for the Air Force.

Following General Allen, Major Gen. Clements McMullen, USAF (Ret.), an IAS Associate Fellow and a charter member, discussed advantages of membership in the Institute.

In executive session, officers of the Section planned a membership drive in the San Antonio area, which includes four Air Force bases and many representatives of the aviation industry.

Colonel Claude W. Smith, Chairman, observed: "With the large number of qualified individuals in the San Antonio area, the local Section should, in the near future, show a 100 per cent increase in membership."

Jesse James Walden, Jr., Manager of the San Antonio office of Convair, A Division of General Dynamics Corporation, was program chairman for the general Section meeting.

J. W. DRAPER, JR., *Secretary*

San Diego Section

H. C. Matteson, Aerodynamics Group Engineer in Convair, San Diego, A Division of General Dynamics Corporation, has been installed as Chairman for the 1956–1957 season and D. P. Germeraad, Chief Engineering Test Pilot of the Division, Vice-Chairman.

Other officers, also installed at the annual business meeting on September 25, are R. A. Fuhrman, Treasurer; M. Herald, Recording Secretary; P. E. Culbertson, Corresponding Secretary; and J. G. Wenzel, Area Councilor Nominee.

Named to the Advisory Management Committee were R. L. Bayless, Chief Engineer, Convair-San Diego; F. E. McCreary, Vice-President—Engineering, Rohr Aircraft Corporation; W. C. Heath, Projects Manager, Solar Aircraft Company; F. W. Fink, Vice-President—Enginering, Ryan Aeronautical Company; and H. I. Mandolph, Vice-President, Langley Corporation.

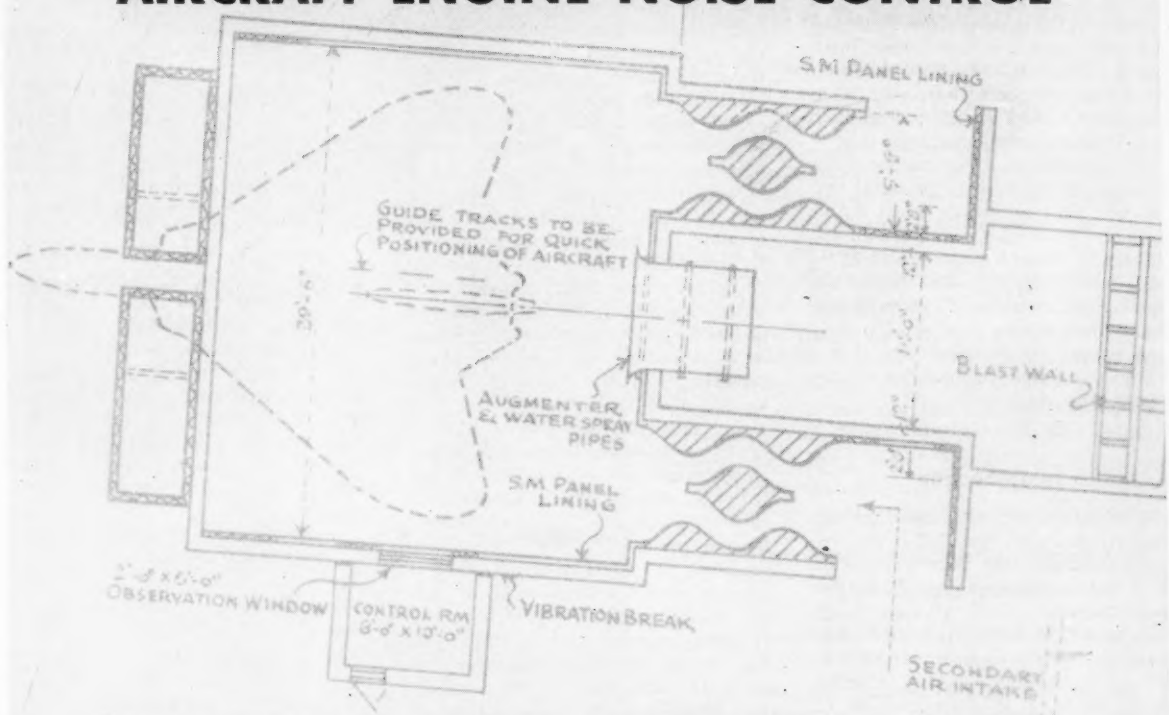
Previous to the installation, William C. Keller, Manager—Customer Relations, Convair-San Diego, discussed the role of the customer relations department as it supports the aircraft industry. He pointed out that customer relations begins when a product idea starts to germinate in the minds of the design engineers and continues through the proposal, sales, and manufacturing areas into the support of delivered equipment in the field. It is necessary that each man in the customer relations department be a specialist in the fields of engineering, sales, contracts, and field support, as well as having high proficiency in the delicate art of personnel relations.

At the September 11 meeting, Charles W. Frick presented a technical paper on "Developments Relative to Supersonic Drag." Mr. Frick joined Convair in the spring of this year and, as Chief of Applied Research, is spearheading various research activities being undertaken by the San Diego Division. For the preceding 15 years, he was at the NACA Ames Aeronautical Laboratory at Moffett Field, Calif., as Chief of the 6-ft. Wind Tunnel Branch and as such was intimately familiar with NACA research activities concerned with supersonic drag developments.

In his paper, Mr. Frick discussed the various phenomena contributing to supersonic drag and the theoretical investigations which have taken place in an effort to understand these phenomena. He gave a brief description of the theoretical work leading up to Richard T. Whitcomb's discovery of the area rule and discussed the extension into the supersonic regime of the application of this concept. The attentive audience asked Mr. Frick numerous questions concerning the applications and limitations of the various theories which have been postulated concerning

Successful Installations

PROVE THAT KOPPERS LEADS IN AIRCRAFT ENGINE NOISE CONTROL



Finest Engineering Service. Complete Line of Equipment. Unmatched Experience.

Koppers Industrial Sound Control's experience, engineering, equipment and number of successful installations stand unchallenged in the suppression of sound for the aircraft industry.

Koppers Industrial Sound Control engineers have silenced aircraft engines of all types, in "hush houses" and with portable run-up mufflers. They have pioneered in the design of sound control equipment to solve the specific problems found in the aircraft industry. Koppers provides complete engineering service . . . including the handling of construction details for entire buildings.

Koppers Industrial Sound Control equipment is now at work suppressing noises for the aircraft industry, for other industries and in air conditioning systems. If you have a sound control problem of any kind, your wisest move is to write KOPPERS COMPANY, INC., Industrial Sound Control Dept., 5908 Scott Street, Baltimore 3, Maryland.

KOPPERS

INDUSTRIAL SOUND CONTROL

Koppers Company, Inc., Metal Products Division
Industrial Sound Control Department

Engineered* Products Sold with *Service

supersonic drag and aircraft performance.

P. E. CULBERTSON, *Secretary*

Seattle Section

Meeting at the Sand Point NAS Commissioned Officers Club, members on September 26 heard Dave North, American Airlines, Inc., representative at Boeing, speak on "Turbo-Prop and Jet Operation Planning." Harlowe Longfelder, outgoing Vice-Chairman, presided in the absence of the Chairman.

Newly elected officers were introduced. They are Lloyd Goodmanson, Chairman; Robert Bateman, Vice-Chairman; Mark Kirchner, Treasurer; and Thomas Davis, Secretary.

Mr. North, with American since 1939, pointed out some of the problems that the air lines anticipate when turbo-prop and jet airplanes are put into use, discussing pavings, noise, maintenance, and traffic control. He offered the opinion that a real market for expansion lies in coach service.

A motion picture showed the Boeing 707 making ramp approaches at the Seattle-Tacoma Airport.

ELAINE GETHING, *Secretary*

Texas Section

New officers and members of the Advisory Board were installed at the September 28 meeting. New officers are R. J. Patton, Chairman; C. L. Turner, Vice-Chairman; A. T. Clemen, Secretary; and E. H. Flath, Treasurer. New Advisory Board members are R. E. Adams, J. H. Boucher, E. F. Cvetko, F. W. Davis, J. R. Duppstadt, G. C. Grogan, E. E. James, J. W. Larson, H. F. Marx, and W. C. Schoolfield.

The membership heard Capt. H. H. Barton, USN, Chief of Staff, Naval Air Advanced Training Command, discuss changes that have taken place in the last few years in Navy aircraft. He stressed the fact that more and somewhat different training is required for jet pilots than was required for pilots of propeller airplanes.

ARTHUR T. CLEMEN, *Secretary*

Tullahoma Section

The ram-jet, offering optimum performance over a broad range of flight conditions, can be tested far better in full-scale facilities, and such facilities are needed sorely, members of the Tullahoma Section were told at their September 25 meeting. The speaker was R. O. Dietz, who presented a paper on "Methods for Planning Ram-Jet Engine Test Facilities" prepared by Mr. Dietz and A. H. Hinners. Both are members of a long-range planning group attached to the Office of the Director of Engineering, ARO, Inc.

Observing that no accepted methods of scaling ram-jet engines are extant, Mr. Dietz showed that selection of an altitude versus Mach Number envelope throughout which the test facility must operate is best accomplished by a study of ram-jet component research. Facility equipment then can be selected from requirements imposed by the operating envelope and expected engine sizes, he said.

Equipment requirements to meet the operating envelope boundaries for four variations in testing techniques were included in Mr. Dietz' report. The variations were listed as free jet with ambient altitude exhaust, free jet with second throat, direct connect with ambient altitude exhaust, and direct connect choked exhaust.

Mr. Dietz declared the successful ram-jet facility planner must carefully monitor and participate in component and overall engine research on ram-jets and other engine types, as well as test techniques employed in full-scale test facilities. Development facility planners also must be aware of development problems to be attacked in the facility being studied, he said.

Size of the facility, Mr. Dietz declared, is determined by the operating envelope and engine size. He said that with the assumption that the exhauster capacity for direct connect choked exhaust nozzle would be one; the capacity required for direct connect ambient altitude exhaust would be eight; for free jet testing with second throats, the exhauster capacity would be three; and for free jet testing with ambient exhaust, the exhauster capacity would be 16. Selection of facility equipment, he said, is based upon a compromise of facility cost and desirable testing techniques.

GENE H. HULL, *Secretary*

Tulsa Section

Richard M. Gilmore, TMIAS, was elected Chairman at the first meeting of the 1956–1957 season on September 12. Robert M. Jenny was chosen Vice-Chairman.

Other new officers are C. K. Barton, Recording Secretary; Ray Diemer, Corresponding Secretary; and L. J. Fila, Treasurer.

After the election, members saw two films—Walt Disney's *History of Aviation* and *Flying Action*—the latter a review of high points in aviation history.

C. K. BARTON, *Secretary*

Washington Section

Spectacular performances by the de-Lackner Aerocycle Flying Platform and Mississippi State College's BLC-equipped Piper Cub, as modified, were witnessed by members as recent guests of the Army Transportation Corps at Fort Belvoir.

Visitors also heard Gen. C. B. DeGavre, introduced by Honorary Chairman William Littlewood, outline the differences between aircraft in respect to their take-off and landing distances. The General intimated that the Army is beginning to realize that too great a price would have to be paid for a vertical take-off feature in an otherwise conventional aircraft and that short take-off airplanes are a better compromise.

On the evening of October 9, the Section held its second meeting of the new season, described as one of the largest dinner sessions ever held in the Washington area.

M. J. Lighthill, Beyer Professor of Applied Mechanics at the University of Manchester, England, addressed the Section on "The Dynamics of Dissociating Gas" at its September 27 meeting. The presentation, concerned with the flow conditions around hypersonic vehicles that result principally from the high temperatures encountered, was similar to one earlier in the year by Dr. Lighthill and proved extremely enlightening to his listeners.

GEORGE T. HAYES, *Secretary*

STUDENT BRANCHES

Agricultural & Mechanical College of Texas

The first meeting of the fall semester was held on September 25 with 50 members present. Chairman Harless R. Benthul conducted the session, introducing the faculty adviser A. E. Cronk, Head of the Department of Aeronautical Engineering.

Professor Cronk introduced members of the faculty and offered to help the branch throughout the year.

A film depicted operation of the Ground Observer Corps and how its activity is coordinated with the Air Defense Command.

A talk on "High-Speed Aerodynamics and Thermodynamics" was slated for the next meeting.

LAWRENCE L. PATTON, *Secretary*

Deadliest fighter plane gets instantaneous control at all altitudes with

HYCO-SPAN CONTROL CABLES

The Convair F-102A supersonic Air Force interceptor can streak into the stratosphere and hunt down an enemy bomber in any kind of weather, day or night. It is packed with the latest electronic gear that locates the target at long range, directs the pilot on the correct attack course, and automatically fires the guided missiles or rockets at the proper instant.

To obtain the most accurate flight control, American Hyco-Span Control Cables were used. These more nearly match the expansion and contraction of aluminum alloy air frames than any other type of control cable. They have a 50% higher coefficient of expansion than the best carbon steel cable . . . one third higher than the best stainless steel cable. As a result, Hyco-Span Cables give you smooth positive control at 70°F *below* zero or 70°F *above*—and without needless extra weight.

Other important advantages of Hyco-Span Cables

1. **Non-magnetic** – do not affect accuracy of sensitive electronic instruments.
2. **Long life** because of excellent corrosion resistance, and low coefficient of friction which permits low cable tension.

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL
General Offices: Cleveland, Ohio
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

Mail the coupon for complete engineering information.

American Steel & Wire
Room 842, Rockefeller Bldg.
Cleveland 13, Ohio

Please send me, without obligation, a copy of your booklet, "Hyco-Span Aircraft Cable," which describes all the important advantages of this control cable.

Name .....
Company .....
Address .....
City & State .....

USS American HYCO-SPAN Aircraft Cables

USS

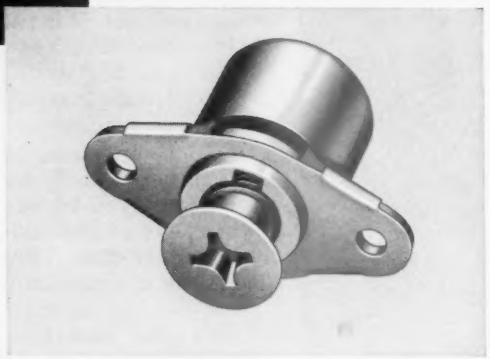
UNITED STATES STEEL

The *New* Pastushin Full-Shear Stress Panel Fastener does what a panel fastener should do!

- absolute positive lock... full shear strength
- automatic spring ejection of stud... no prying to free panel
- curved panel is no problem
- only two assemblies (self-retained)... stud and retainer
- no special installation tools... Phillips head recess

PATENT PENDING

Available now in quantity!



Fastens and unfastens a panel faster and easier than any other fastener on the market!

Check these important features:

Full Shear Strength... stud design transmits full shear strength equal to NAS-547 specification, and/or NAS 334-335 close tolerance bolt.

Positive Mechanical Lock... when stud is seated, it's locked! Visual inspection assures safe lock.

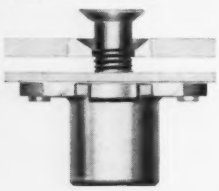
Automatic Stud Ejection... when stud is released, it is automatically spring-ejected from the retainer, allowing panel removal without forcing or prying.

Curved Panels offer no problem...small radius of entry of stud into retainer assembly allows installation and operation on surfaces of less than one inch radius.

Double Lead Stud Thread... assures top performance and trouble-free long service life.

Materials and Finishes... critical bearing surfaces are of CM steel, heat treated to rigid specifications. Steel parts are cadmium plated, aluminum alloy parts anodized.

This is the actual size of the ¼" fastener assembly ... tiny, lightweight and strong. The 5/16" unit is proportionately larger.



Write for complete information on Pastushin's Full-Shear Stress Panel Fasteners, designed for high-strength and simplified securing of access panels and equipment on modern aircraft.

PASTUSHIN INDUSTRIES, INC.

5651 WEST CENTURY BOULEVARD, LOS ANGELES, CALIFORNIA

Affiliate Companies

PASTUSHIN AVIATION CORP., Los Angeles, California | HAWAIIAN AIRMOTIVE, LTD., Honolulu, Hawaii

DEVELOPERS AND MANUFACTURERS OF AIRCRAFT FASTENERS

Georgia Institute of Technology

J. E. York, of Lockheed Aircraft Corportation, addressed the Branch on "Aircraft Structures at Lockheed" at its first meeting of the fall semester. Two film shorts outlined progress made during the last year on the C-130 Hercules and the B-47.

A general discussion was held on the excellent showing by Virginia Polytechnic Institute at the last IAS Regional Student Conference, as compared to the apparent lack of interest at Georgia Tech. It was decided that not enough time could be sacrificed by the senior undergraduate to write a paper worthy of delivery, and a proposal is to be made to the faculty that some quarter hours be granted if such a project is undertaken.

Also discussed were procedures necessary for student membership in the IAS. Chairman Fred DeJarnette presided.

EUGENE C. KNOX, *Secretary*

Iowa State College

A British film on powered flight was shown to members at the opening fall meeting on October 3. The film depicted the advances made in aviation since the beginning of powered flight and emphasized the contribution of Great Britain.

An invitation had been extended to all freshmen aeronautical engineering students to attend the meeting. The response was gratifying.

MARVIN BAXENDALE, *Secretary*

Kansas State College

The first Branch meeting of the new school year was held on September 20, with 15 members present. Keith Small, Chairman, spoke on the advantages of student membership in the IAS and discussed benefits derived from such an affiliation.

Frank J. McCormick, Professor of Applied Mechanics, faculty adviser, outlined the annual paper competition sponsored by the Texas Section, in which the Kansas State Branch has participated for the last 3 years, and reminded the group that the earlier a paper is finished, the more polished it would become—if worked on—for the competition.

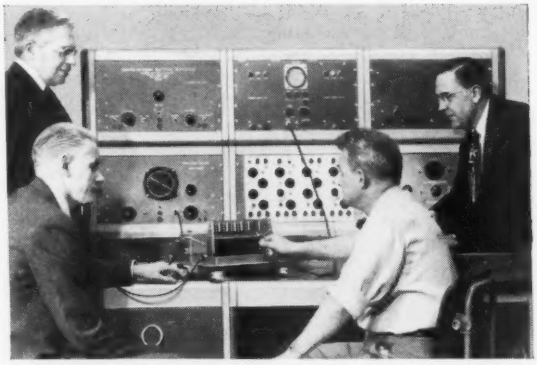
A short discussion was held on future programs, and the meeting closed by showing of a film depicting the growth of the aviation industry.

NOR SUTTON, *Secretary*

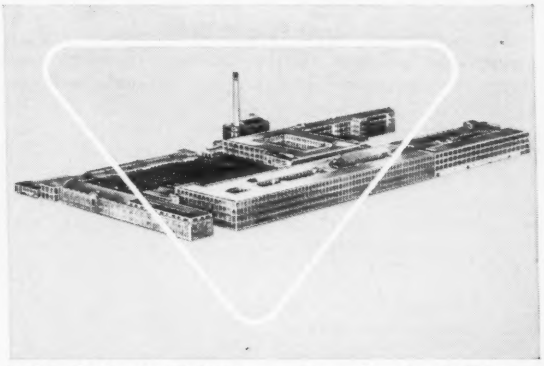
North Carolina State College

About 50 students attended the first meeting of the Branch on September 25. All aeronautical engineering students had been invited, and letters outlining

The *right* people with the *right* facilities produce the *right* solutions



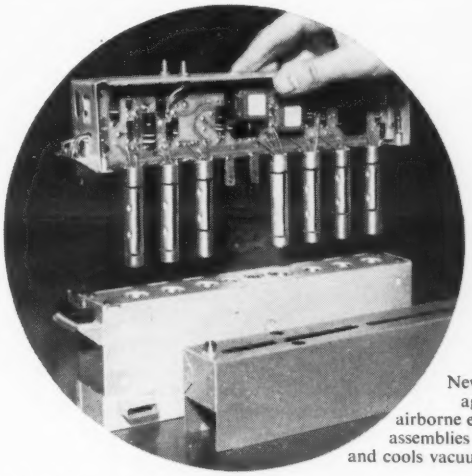
Observing measurement of circuit parameters in the Electronic Systems Division's Buffalo Engineering Laboratory. From left: H. S. Tittle, Manager—Buffalo Operations; M. C. Scott, Manager—Buffalo Engineering Laboratory; R. W. Ferry, Advanced Development Engineer; and A. W. Puttick, Engineering Manager.



Buffalo Engineering Laboratory and manufacturing facilities occupy nearly 170,000 square feet of floor space in this industrial center at 175 Great Arrow Ave., Buffalo 7, New York.

Keeping electronic equipment cool

with controlled air flow "Packaging"



New "packaging" for airborne electronic assemblies insulates and cools vacuum tubes.

INTENSE HEAT generated by airborne electronic equipment and supersonic flight is posing new problems for the safety and performance both of crewmen and their planes.

An ingenious method for combating the heat menace was recently developed by Sylvania's Electronic Systems Division. Vacuum tubes are mounted in carefully sized ducts in light foam plastic material of the desired thermal properties. Accurately controlled air flow results in optimum cooling, while exhausting the air at high temperature.

Tests have proved that this is an extremely effective method, giving cooling efficiencies of approximately 90 per cent. Through the use of such electronic "packing" in supersonic aircraft, it is possible to reduce the amount of air-cooling equipment, with its accompanying weight penalties.

Problem solving, whether in research and development or in practical application, is the chief task of Sylvania's Electronic Systems Division. In all of its installations, the right people work with the right facilities, within a sound managerial environment. That is why they have produced right solutions to a variety of problems, and have made many important contributions in the fields of aviation electronics, guided missiles, countermeasures, communications, radar, computers, and control systems. Whether the problem is military or industrial, Sylvania's business is to come up with solutions that are producible.

The Electronic Systems Division has plant and laboratory facilities at Buffalo, N. Y., Mountain View, Calif., and Waltham, Mass. All are staffed with top-ranking scientists and engineers, backed with Sylvania's extensive resources in the electronics field.

SYLVANIA IS LOOKING FOR ENTERPRISING ENGINEERS

Sylvania has many opportunities in a wide range of defense projects. If you are not now engaged in defense work, you are invited to contact Edward W. Doty, Manager of Personnel, Electronic Systems Division, Sylvania Electric Products Inc., 100 First Avenue, Waltham 54, Mass.

SYLVANIA

SYLVANIA ELECTRIC PRODUCTS INC.

LIGHTING • RADIO • ELECTRONICS • TELEVISION • ATOMIC ENERGY • CHEMO-METALLURGY

merits of the IAS and student membership were sent to freshmen.

Chairman Dave Pierce opened the meeting with a short talk in which he explained the purposes of the IAS. Robert M. Pinkerton, Professor of Aeronautical Engineering, welcomed those present. A film, outlining the progress of aviation since the early days, followed.

A tour of the Wind Tunnel and Structures Laboratories closed the meeting.

JESSE W. HARRELL, *Secretary*

Oklahoma Agricultural & Mechanical College

Eighteen members and seven guests were present on September 27 as the Branch began a new year. Plans for the fall semester were discussed under the leadership of Thomas E. Determan, Chairman.

The evening's program was conducted by Aggies who told of their summer work experiences. Places of employment and those who told of their summer on-the-job experiences were: Douglas Aircraft—James S. Jones, Thomas E. Determan, James M. Ellis, and Glenn R. Hubby; Convair—Lyle E. Becknell; North American—Louis W. Power; Tinker Air Force Base—Ronald D. Johnson; Chance Vought—Patrick Z. Wyers.

Out of the talks came the following conclusions: Almost all of the workers enjoyed their assignments; personnel under whom they worked were helpful and considerate; working conditions were the finest; and salaries paid and traveling expenses allowed were satisfactory.

PATRICK Z. WYERS
Corresponding Secretary

Parks College of Aeronautical Technology

Led by their Honorary Chairman, Richard B. Trefney, members of the Parks Branch on September 20 discussed IAS activities, placing emphasis on student paper competitions. Mr. Trefney is Director of the Aeronautical Engineering Department.

Because the Branch has lost some members through graduation, an effort is being made to place the advantages of student membership before as many students as possible.

RICHARD M. ANDRES, *Secretary*

The Pennsylvania State University

This year the Branch tried a new idea in preparing its annual program. During the summer, the Executive Committee corresponded with several industrial organizations and scheduled a nearly complete program of speakers, topics, and speaking dates for the year. The Committee now is free to use its time to attend to the details of program presentation and to formulating other activities.

Seventy engineering students were present as the Branch held its first meeting of the 1956–1957 school year on September 27. Chairman William J. Kleinbauer, Jr., welcomed new members. John A. Fox, faculty adviser and Instructor in Aeronautical Engineering, outlined the advantages of IAS membership and urged members to prepare papers to be presented at meetings. Robert H. Dunkelberger was elected Vice-Chairman to fill the only vacancy in the roster of officers.

After a discussion of future IAS activities, a film entitled *We Saw It Happen*, available through the IAS, was shown. A social period, including refreshments, followed.

ROBERT L. WALACAVAGE, *Secretary*

Rensselaer Polytechnic Institute

Chairman Dale Martin presided over the opening meeting of the school year on September 19, outlining purposes and advantages of IAS membership—a subject later elaborated upon by H. C. Mattice. Professor Mattice is faculty adviser. About 160 were present.

Other officers, introduced by Chairman Martin, were Peter Tennen, Vice-Chairman; Robert Kelly, Secretary-Treasurer; and Rudy Swigart, Program Chairman.

Three films were shown. *Portrait of the Earth* produced by Hycon Manufacturing Company, discussed aerial photography and both the stereoscopic and electron methods of aerial photograph reproduction. It also reviewed such devices as the hydrogen magnetometer and scintillator—employed for locating minerals from the air.

A North American Aviation film, *Engineering for Tomorrow*, reviewed the steps in the complete development and production of a guided missile.

Industrial Research and Development, prepared by Hughes Aircraft, examined some of the firm's projects. These included fire control systems, silicon transistors, and electron storage tubes.

ROBERT E. KELLY
Secretary-Treasurer

University of Detroit

In the belief that new students in the Aeronautical Engineering Department are valuable members, even though they may not participate in Branch activities fully, this Branch is making an effort to contact all freshmen enrolled in the Department.

At the first meeting of the new semester, an informal discussion was held as to whether the Student Council representative for the IAS Branch should vote that the Engineering Show, held biannually at this university, should have an extra show in 1961 or whether the 1960 program should be postponed a year. This is necessary so that a show may take place during the 50th anniversary of the university. Members take an active part in this program, which is attended by a large part of the Detroit population.

Plans were made to hear a speaker from Cessna Aircraft on preliminary design. Several members have agreed to speak at meetings on advantages of the cooperative plan that is part of the engineering course at the University of Detroit during the third, fourth, and fifth years in the curriculum. This Branch has two meetings each month, bringing up the question of the formal interval between meetings. In this connection, it would be interesting to hear from other Branches their experiences in this regard.

DAVID P. DURST
Acting Secretary

University of Illinois

Roger Mueller has been elected Branch Chairman for the 1956–1957 school year, with the following consisting of the remainder of the slate: Donald Glennie, Vice-Chairman; Eugene G. Hill, Secretary; James Christensen, Treasurer; and Donald Eckert and Ronald Fross, Engineering Council Representatives. Mr. Mueller succeeds Joseph Voda.

The Branch's Annual Banquet on May 8 lived up to its advance billing as a highlight of the year. It was held jointly with Sigma Gamma Tau, aeronautical engineering honor society.

Guest speaker was C. G. Whittenbury, who received a Bachelor of Science degree in Honours Physics from Manchester University, earned a Master of Science degree in Aeronautical Engineering at the University of Illinois, and is studying here for his doctoral.

Speaking on "Aeronautical Engineering Education in England," Mr. Whittenbury compared the systems of England and the United States from the standpoint of technical and general training, discussing points which he thought were good and those which could be improved upon.

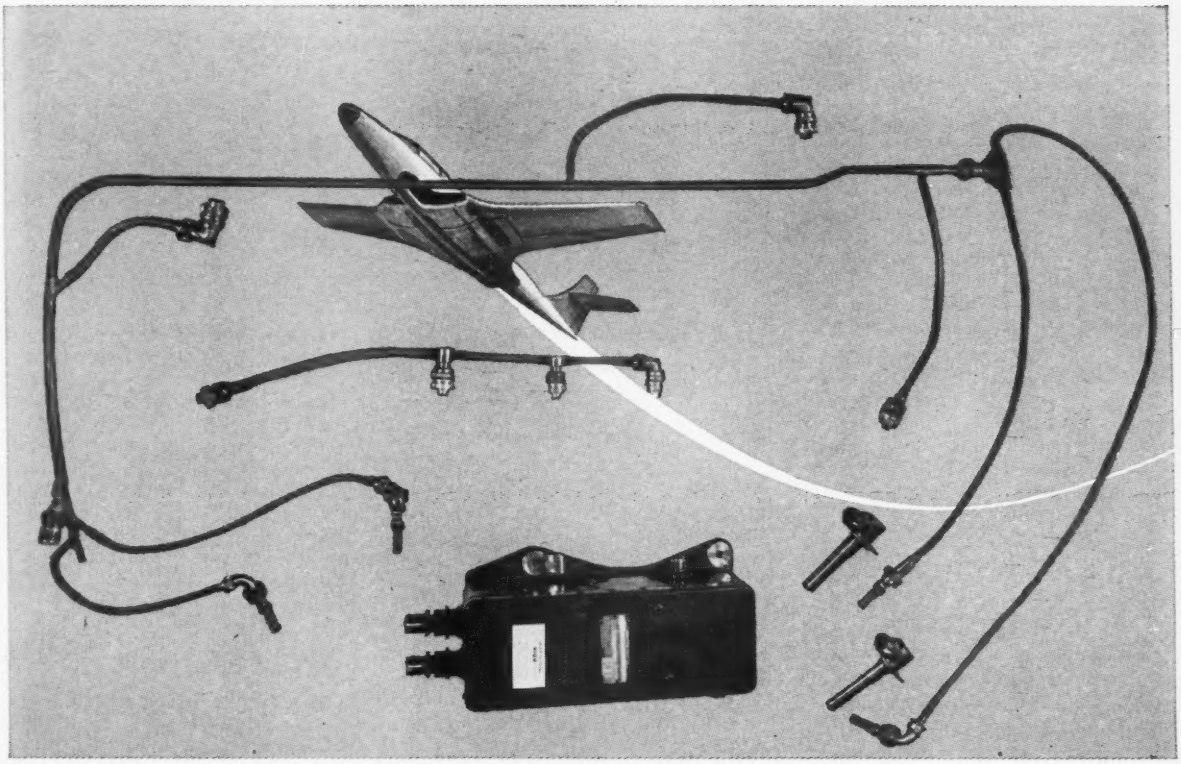
EUGENE G. HILL, *Secretary*

University of Kansas

R. H. Hepper, of McDonnell Aircraft Corporation, addressed Branch members on September 18 on "Designing for High-Speed Cooling," outlining the cause of aerodynamic heating of a structure in a supersonic or hypersonic missile.

Mr. Hepper, Project Group Engineer, told of ways of minimizing elevated

Bendix AND ONLY Bendix



Offers a Complete Ignition System for JET ENGINES!

The most significant reason why the Scintilla Division of Bendix has long been recognized as the leader in aviation ignition is that Bendix-Scintilla designs, engineers and manufactures every component of the ignition system.

Obviously, components designed to work together give more efficient performance and require less attention in original installation or later service.

That is why Bendix and only Bendix offers the industry a complete jet ignition system, including, not only the ignition unit, but igniter plug leads, igniter plugs and control harness as well.

There just isn't any question about it—you get not only the best, but all of the best when you specify Bendix for your complete jet engine ignition requirements.

Bendix SCINTILLA DIVISION OF Bendix AVIATION CORPORATION
SIDNEY, NEW YORK

Export Sales and Service: Bendix International Division, 205 East 42nd St., New York 17, N.Y.
Canadian affiliate, Aviation Electric Limited, 200 Laurentien Blvd., St. Laurent, Montreal 9, Quebec, Canada.

FACTORY BRANCH OFFICES:
117 E. Providencia Avenue, Burbank, California • 512 West Avenue, Jenkintown, Pennsylvania • Paterson Building, 18038 Mack Avenue, Detroit 24, Michigan • 5906 North Port Washington Road, Milwaukee 17, Wisconsin • Hulman Building, 120 W. Second Street, Dayton 2, Ohio • 8401 Cedar Springs Road, Dallas 19, Texas • Boeing Field, Seattle 8, Washington • 1701 "K" Street, N.W., Washington 6, D. C.

Bendix
SCINTILLA DIVISION
Bendix AVIATION CORPORATION

merits of the IAS and student membership were sent to freshmen.

Chairman Dave Pierce opened the meeting with a short talk in which he explained the purposes of the IAS. Robert M. Pinkerton, Professor of Aeronautical Engineering, welcomed those present. A film, outlining the progress of aviation since the early days, followed.

A tour of the Wind Tunnel and Structures Laboratories closed the meeting.

JESSE W. HARRELL, *Secretary*

Oklahoma Agricultural & Mechanical College

Eighteen members and seven guests were present on September 27 as the Branch began a new year. Plans for the fall semester were discussed under the leadership of Thomas E. Determan, Chairman.

The evening's program was conducted by Aggies who told of their summer work experiences. Places of employment and those who told of their summer on-the-job experiences were: Douglas Aircraft—James S. Jones, Thomas E. Determan, James M. Ellis, and Glenn R. Hubby; Convair—Lyle E. Becknell; North American—Louis W. Power; Tinker Air Force Base—Ronald D. Johnson; Chance Vought—Patrick Z. Wyers.

Out of the talks came the following conclusions: Almost all of the workers enjoyed their assignments; personnel under whom they worked were helpful and considerate; working conditions were the finest; and salaries paid and traveling expenses allowed were satisfactory.

PATRICK Z. WYERS
Corresponding Secretary

Parks College of Aeronautical Technology

Led by their Honorary Chairman, Richard B. Trefney, members of the Parks Branch on September 20 discussed IAS activities, placing emphasis on student paper competitions. Mr. Trefney is Director of the Aeronautical Engineering Department.

Because the Branch has lost some members through graduation, an effort is being made to place the advantages of student membership before as many students as possible.

RICHARD M. ANDRES, *Secretary*

The Pennsylvania State University

This year the Branch tried a new idea in preparing its annual program. During the summer, the Executive Committee corresponded with several industrial organizations and scheduled a nearly complete program of speakers, topics, and speaking dates for the year. The Committee now is free to use its time to attend to the details of program presentation and to formulating other activities.

Seventy engineering students were present as the Branch held its first meeting of the 1956–1957 school year on September 27. Chairman William J. Kleinbauer, Jr., welcomed new members. John A. Fox, faculty adviser and Instructor in Aeronautical Engineering, outlined the advantages of IAS membership and urged members to prepare papers to be presented at meetings. Robert H. Dunkelberger was elected Vice-Chairman to fill the only vacancy in the roster of officers.

After a discussion of future IAS activities, a film entitled *We Saw It Happen*, available through the IAS, was shown. A social period, including refreshments, followed.

ROBERT L. WALACAVAGE, *Secretary*

Rensselaer Polytechnic Institute

Chairman Dale Martin presided over the opening meeting of the school year on September 19, outlining purposes and advantages of IAS membership—a subject later elaborated upon by H. C. Mattice. Professor Mattice is faculty adviser. About 160 were present.

Other officers, introduced by Chairman Martin, were Peter Tennen, Vice-Chairman; Robert Kelly, Secretary-Treasurer; and Rudy Swigart, Program Chairman.

Three films were shown. *Portrait of the Earth* produced by Hycon Manufacturing Company, discussed aerial photography and both the stereoscopic and electron methods of aerial photograph reproduction. It also reviewed such devices as the hydrogen magnetometer and scintillator—employed for locating minerals from the air.

A North American Aviation film, *Engineering for Tomorrow*, reviewed the steps in the complete development and production of a guided missile.

Industrial Research and Development, prepared by Hughes Aircraft, examined some of the firm's projects. These included fire control systems, silicon transistors, and electron storage tubes.

ROBERT E. KELLY
Secretary-Treasurer

University of Detroit

In the belief that new students in the Aeronautical Engineering Department are valuable members, even though they may not participate in Branch activities fully, this Branch is making an effort to contact all freshmen enrolled in the Department.

At the first meeting of the new semester, an informal discussion was held as to whether the Student Council representative for the IAS Branch should vote that the Engineering Show, held biannually at this university, should have an extra show in 1961 or whether the 1960 program should be postponed a year. This is necessary so that a show may take place during the 50th anniversary of the university. Members take an active part in this program, which is attended by a large part of the Detroit population.

Plans were made to hear a speaker from Cessna Aircraft on preliminary design. Several members have agreed to speak at meetings on advantages of the cooperative plan that is part of the engineering course at the University of Detroit during the third, fourth, and fifth years in the curriculum. This Branch has two meetings each month, bringing up the question of the formal interval between meetings. In this connection, it would be interesting to hear from other Branches their experiences in this regard.

DAVID P. DURST
Acting Secre.ary

University of Illinois

Roger Mueller has been elected Branch Chairman for the 1956–1957 school year, with the following consisting of the remainder of the slate: Donald Glennie, Vice-Chairman; Eugene G. Hill, Secretary; James Christensen, Treasurer; and Donald Eckert and Ronald Fross, Engineering Council Representatives. Mr. Mueller succeeds Joseph Voda.

The Branch's Annual Banquet on May 8 lived up to its advance billing as a highlight of the year. It was held jointly with Sigma Gamma Tau, aeronautical engineering honor society.

Guest speaker was C. G. Whittenbury, who received a Bachelor of Science degree in Honours Physics from Manchester University, earned a Master of Science degree in Aeronautical Engineering at the University of Illinois, and is studying here for his doctoral.

Speaking on "Aeronautical Engineering Education in England," Mr. Whittenbury compared the systems of England and the United States from the standpoint of technical and general training, discussing points which he thought were good and those which could be improved upon.

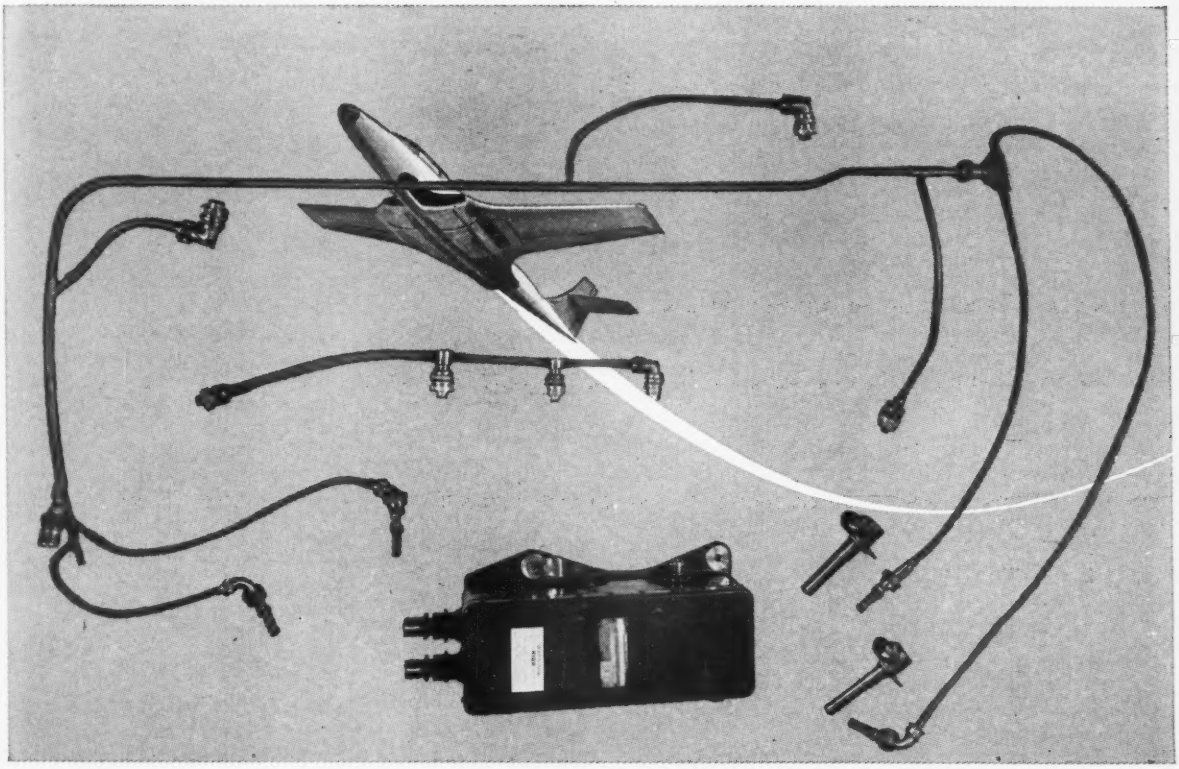
EUGENE G. HILL, *Secretary*

University of Kansas

R. H. Hepper, of McDonnell Aircraft Corporation, addressed Branch members on September 18 on "Designing for High-Speed Cooling," outlining the cause of aerodynamic heating of a structure in a supersonic or hypersonic missile.

Mr. Hepper, Project Group Engineer, told of ways of minimizing elevated

Bendix AND ONLY Bendix



Offers a Complete Ignition System for JET ENGINES!

The most significant reason why the Scintilla Division of Bendix has long been recognized as the leader in aviation ignition is that Bendix-Scintilla designs, engineers and manufactures every component of the ignition system.

Obviously, components designed to work together give more efficient performance and require less attention in original installation or later service.

That is why Bendix and only Bendix offers the industry a complete jet ignition system, including, not only the ignition unit, but igniter plug leads, igniter plugs and control harness as well.

There just isn't any question about it—you get not only the best, but all of the best when you specify Bendix for your complete jet engine ignition requirements.

Bendix SCINTILLA DIVISION OF Bendix AVIATION CORPORATION
SIDNEY, NEW YORK

Export Sales and Service: Bendix International Division, 205 East 42nd St., New York 17, N.Y.
Canadian affiliate, Aviation Electric Limited, 200 Laurentien Blvd., St. Laurent, Montreal 9, Quebec, Canada.

FACTORY BRANCH OFFICES:
117 E. Providencia Avenue, Burbank, California • 512 West Avenue, Jenkintown, Pennsylvania • Paterson Building, 18038 Mack Avenue, Detroit 24, Michigan • 5906 North Port Washington Road, Milwaukee 17, Wisconsin • Hulman Building, 120 W. Second Street, Dayton 2, Ohio • 8401 Cedar Springs Road, Dallas 19, Texas • Boeing Field, Seattle 8, Washington • 1701 "K" Street, N.W., Washington 6, D. C.

Bendix
SCINTILLA DIVISION
Bendix AVIATION CORPORATION

temperatures by insulating and cooling and through design methods. Slides augmented his talks. A question-answer period followed.

Members also saw a film on *Naval Qualification Tests*.

NANCY SMITH, *Secretary*

University of Virginia

Members of the Branch on October 8 heard James E. May, Associate Professor of Mechanical Engineering, present a short lecture on "Opportunities in Engineering Industry." Chairman Deane V. Weihe presided.

Professor May outlined the various types of assignment a novice engineer could expect to be called upon to perform. He also discussed the role of an engineer in aeronautical engineering and also in the related administrative fields.

A large portion of the meeting was devoted to the forming of committees to formulate plans for the year's program. Committees also were named to prepare for the Second Annual Middle Atlantic Area Conference of the student branches of the IAS.

JOHN K. HALEY, *Secretary*

University of Wichita

Everett Cook, Instructor in Aeronautical Engineering, faculty adviser, spoke to members at the October 9 meeting on the functions of the IAS, both student and technical, and told them about IAS meetings, publications, and types of membership.

Chairman Jack Wolf followed up Mr. Cook's talk with an enumeration of some of the advantages of being a Student Member of the IAS. Among them he listed reduced subscription rates for IAS publications, student paper competitions, the Flight Test Engineering Fellowship, and the IAS library and film services.

After an outline by Chairman Wolf on plans for the semester, the meeting was concluded.

WARREN F. CHICHESTER, *Secretary*

West Virginia University

Student members and guests heard an address on September 19 by Leon Zee Seltzer, Professor and Head of the Aeronautical Engineering Department, on the goals of the IAS. Thomas Murphy, Robert Hammond, and George Poisal told other students of experiences during the summer as temporary workers in industry.

Professor Seltzer outlined advantages of IAS membership to students both before and after graduation. He spoke of the awards given by the Student Branch and of the regional conferences and opportunities to present papers in competition for cash awards.

Students also learned of the fire that during the summer destroyed Mechanical Hall and how the Aeronautical Engineering Department was involved. A benefit that followed the fire was the Department's acquisition of the most modern and best equipment available.

It was also announced that the Department has purchased a new Cessna 182, complete with single-axis autopilot, Omni, ADF, and Speed Control Indicator.

CALVIN F. WILSON
Corresponding Secretary

MEMBERS ELECTED

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the Review.

Elected to Associate Fellow Grade

Garrard, E. C., Chief Designer, The Fairey Aviation Co. of Canada, Ltd.

Transferred to Associate Fellow Grade

Brodsky, Robert F., M.S., Chief of Aerodynamics, Convair, Pomona, A Div. of General Dynamics Corp.

Busch, Gerald A., M.S., Devel. Planning Specialist, Lockheed Aircraft Corp. (Burbank).

Elected to MEMBER Grade

Anderson, Elmer C., B.S.M.E., Design Engr., Lockheed Aircraft Corp. (Burbank).

Birnbaum, Sidney, M.S., Sr. Dynamics Engr., The Glenn L. Martin Co.

Bridgeman, Harry M., A.B., Manager, Economics Research, Stanford Research Institute (South Pasadena).

Creedon, Anthony M., Asst. Chief Stressman, Auster Aircraft, Ltd. (Leics).

Dodge, Sherwood H., M.S. in Ae.E., Capt., USN; Dir., Aircraft Production Resources Agency (Wright-Patterson AFB).

Dyda, Kenneth J., B.S. in M.E., Aerodynamicist, North American Aviation, Inc. (Los Angeles).

Ellisman, Carl, B.S.M.E., Head, Aero. Engrg. Branch, U.S. Naval Air Missile Test Center (Point Mugu).

Glynn, James R., B. of Ae.E., Group Engr., Boeing Airplane Co.

Greil, Karl F., Propulsion Staff Engr., The Glenn L. Martin Co.

Harlan, Robert B., Jr., Manager, Western Region, Pesco Products Div., Borg-Warner Corp. (Bedford).

Hearin, Jesse B., Jr., B.S., Airborne Weapon System Engr., General Electric Co. (Cincinnati).

Honecker, Herbert J., Jr., B.S., Aero. Research Engr., U.S. Naval Ordnance Labs. (Silver Spring).

Horner, John W., S.B.M.E., Engr., Prelim. Design, North American Aviation, Inc. (Downey).

Hughes, Whitney D., Design Weight Engr., Northrop Aircraft, Inc.

Jacobson, Ronnie, A.A., Group Supvr., Radioplane Co.

Kartasuk, Raymond H., B.S., Sr. Engr., Aerodynamics, Cook Research Laboratories Div., Cook Electric Co.

Kennedy, Richard R., B.S.M.E., Sr. Liaison Engr., Chance Vought Aircraft, Inc.

Kerrebrock, Jack L., Ph.D., Research Fellow, California Institute of Technology.

Kettler, Jack R., M.S., Asst. Proj. Engr., AiResearch Manufacturing Co. Div., The Garrett Corp.

Kondo, Jiro, M. of Engrg., Prof., Dept. of Aero., Univ. of Tokyo.

Lair, Robert C., B.S.M.E., Jr. Stress Engr., Goodyear Aircraft Corp.

Lundgren, Stig, B.S., Dynamics Engr., Lockheed Aircraft Corp. (Burbank).

Mammola, Anthony, Designer, East Coast Aeronautics, Inc.

Neighbors, Thomas H., Jr., Supvr., Field Service Tech. Group, Lockheed Aircraft Corp. (Marietta).

Neuffer, Bruce H., B.S. in M.E., Supvr., Prelim. Design, AGT Div., General Electric Co. (Cincinnati).

Nial, Walter R., B. of Ae.E., Manager, Fluid Mechanics and Combustion, General Electric Co. (Schenectady).

O'Brien, Robert F., Chief Engr., De Luca Co.

O'Bryan, Thomas C., B.S., Aero. Research Scientist, NACA (Langley Field).

Radcliffe, William F., M.S. in Math., Chief, Aerophysics Group, Convair, San Diego, A Div. of General Dynamics Corp.

Remmer, Henry J., B.S. in M.E., Asst. Chief, Pratt & Whitney Aircraft Div., United Aircraft Corp.

Rex, Edward M., B.S. in M.E., Lt. Col., USAF; Assoc. Prof., Dept. of Mech. Engrg., Air Force Institute of Technology (Wright-Patterson AFB).

Schenk, Frederick L., B.E.E., Devel. Engr., Aeronautical Div., Minneapolis-Honeywell Regulator Co.

Schoolfield, Daniel R., B.S.E.E., Engrg. Test Pilot, Temco Aircraft Corp.

Weisblatt, Herbert, B.S. in M.E., Assoc. Scientist, Avco Manufacturing Corp.

Whiteley, James M., B.S., Aerodynamics Engr., Convair, Ft. Worth, A Div. of General Dynamics Corp.

Wilkins, Wendell C., B. in Ae.E., Asst. Chief Controls Engr., Douglas Aircraft Co., Inc. (El Segundo).

Wong, Gordon, B. of Engrg., Struct. Engr., North American Aviation, Inc. (Los Angeles).

Transferred to MEMBER Grade

Brulle, Robert V., M.S., Capt., USAF; Asst. Prof., Air Force Institute of Technology (Wright-Patterson AFB).

Bush, Harry L., B.S., Lt. Col., USA; Student, Command and General Staff College (Ft. Leavenworth).

Clanton, Ronald G., B.S. in M.E., Group Leader, Systems Analysis, Westinghouse Electric Corp. (Baltimore).

Culbertson, Philip E., M.S. in Aerodynamics, Staff Engr. to V-P, Convair, San Diego, A Div. of General Dynamics Corp.

Fox, John E., Aircraft Design Engr., Special Proj. Div., Lockheed Aircraft Corp. (Marietta).

Gandy, Charles L., Jr., B.S., Capt. USAF; Experimental Flight Test Officer (Edwards AFB).

Geiger, Robert C., B.S. in Ae.E., Group Engr., Missile Systems Div., Lockheed Aircraft Corp. (Van Nuys).

Green, Joseph, B.S. in Ae.E., Major, Kc-135 Unit Chief, USAF (Castle AFB).

Lindsay, Russell C., B.S. in Ae.E., Sr. Prelim. Designer, Goodyear Aircraft Corp.

Lorenz, Sigmund J., Engr., Vertol Aircraft Corp.

Millikan, David L., B.S., Asst. Proj. Engr., Cornell Aeronautical Laboratory, Inc.

Romig, Mary F., B.S., Staff Scientist, Convair, San Diego, A Div. of General Dynamics Corp.

Smiley, Robert F., B.S. in E.E., Aero. Research Scientist, NACA (Langley Aeronautical Lab.).

Snyder, Philip S., Staff Engr., North American Aviation, Inc. (Los Angeles).

Stroud, George R., Jr., B.S. in Ae.E., Sr. Designer, Landing Gear, Chance Vought Aircraft, Inc.

West, Charles D., B.S. in Ae.E., Engr., Applied Physics Lab., The Johns Hopkins Univ.

Elected to Associate Member Grade

Bernhardt, Allan, Asst. Editor, AERONAUTICAL ENGINEERING REVIEW, Institute of the Aeronautical Sciences, Inc.

Welden, Bill, Field Service Engr., Westinghouse Electric Corp. (Kansas City).

Elected to Technical Member Grade

Bass, William A., III, B.S.M.E., Assoc. Engr., Douglas Aircraft Co., Inc. (Long Beach).

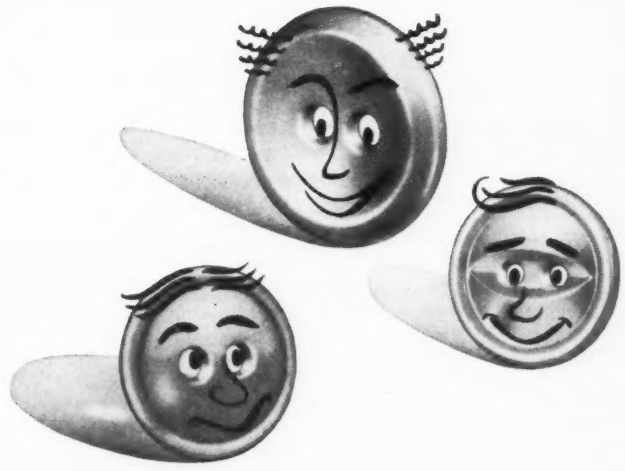
Boling, David E., Devel. Engr., McDonnell Aircraft Corp.

Graef, Jack D., S.B., Flight Test Engr., Douglas Aircraft Co., Inc. (Santa Monica).

Greene, Frank L., B.E.E., Engr., Sperry Gyroscope Co.

Grimm, Richard G., B.S.M.E., Assoc. Engr., Northrop Aircraft, Inc.

Our Engineers are bright as buttons



and they aren't on pins and needles

Kaman Engineers are a shirtsleeves bunch with a tremendous job to do and the pride and ability to do it. Part of their driving incentive is the relaxed atmosphere found everywhere at Kaman. You may be sure, though, that every man is pulling his own weight and then some.

The many new products and the large number of aeronautical "firsts" that have come from Kaman in ten short years attest to the quiet efficiency with which Kaman engineers, and all the Kaman people, go about their business.

It is apparent that such industry and ability are rewarded. In addition to the well earned pat on the back, Kaman makes its appreciation tangible with top level salaries, opportunities and working conditions.

Here's your chance to button down the job you've been wanting. Check the position you can fill and return the coupon with a brief resume, *now*.

KAMAN

THE KAMAN AIRCRAFT CORP.
61 Old Windsor Road
Bloomfield, Conn.

Att: W. M. Tynan, Administrative Engineer

Name_____
Address_____
City_____
State_____
Home Phone_____

- ☐ Aerodynamics
- ☐ Design Drafting & Layout
- ☐ Dynamics
- ☐ Electrical Design & Layout
- ☐ Electronics
- ☐ Liaison
- ☐ Mechanical Design
- ☐ Preliminary Design & Research
- ☐ Stress Analysis
- ☐ Systems Development
- ☐ Structural Design
- ☐ Test & Development
- ☐ Thermodynamics
- ☐ Weights

Hammer, Carl F., Jr., B.A. in Math., Assoc. Engr., Douglas Aircraft Co., Inc. (Long Beach).

Pincombe, Charles A., M.A., Design Draftsman, Bell Aircraft Corp.

Tirumalesa, Duvvuri, M.S. in Physics, Research Scholar, Institut Blaise Pascal (Chatillon).

Transferred to Technical Member Grade

Aichroth, Wayne W., B.S., Engr., Ford Aircraft Engine Div. (Chicago).

Babits, George F., B.S. in Ae.E., Lt. Col., USAF; Student Duty Station, California Institute of Technology.

Bartleson, Harold J., B.S., Flight Test Engr., Convair, San Diego, A Div. of General Dynamics Corp.

Battaglia, Philip J., B.S. in Ae.E., Assoc. Engr., The Glenn L. Martin Co.

Billingsley, James P., B.S., Aerodynamics Engr., Convair, Pomona, A Div. of General Dynamics Corp.

Boyle, Thomas E., Assoc. Aero. Engr., Convair, San Diego, A Div. of General Dynamics Corp.

Bracka, Bruno W., B.A.S., Design Engr., Convair, San Diego, A Div. of General Dynamics Corp.

Brandt, Robert L., B.S. in Ae.E., Capt., USAF; Proj. Engr., ARDC Det. #1 (Wright-Patterson AFB).

Brogan, Thomas B., B. of Engrg. Physics, Assoc. Engr., Avco Manufacturing Corp.

Brown, Stanley B., B.S., in Ae.E., Field Service Engr., Douglas Aircraft Co., Inc. (El Segundo).

Burger, Donald W., B.S., 2nd Lt., USAF; Student Officer in Primary Pilot Training (Moore Air Base).

Burke, William F., Lt., USN; Flight Instructor (Barin Field).

Burritt, John C., B.S. in Air Transportation, Aviation Officer Candidate, USN (Pensacola).

Calligeros, John M., S.M. in Ae.E., Staff Research Engr., Massachusetts Institute of Technology.

Chen, William S., M.S. in Ae.E., Research Engr., Jet Propulsion Laboratory, California Institute of Technology.

Christman, Clyde C., Jr., B.A.E., Aero. Engr., Lockheed Aircraft Corp. (Van Nuys).

Cohen, Milton H., B.Ae.E., Wind Tunnel Test Engr., North American Aviation, Inc. (Los Angeles).

Cusworth, Maynard C., Capt., USAF; Maintenance Officer (Seattle).

Derrick, Arthur C., B.S., Lt., USN; Student, Stevens Institute of Technology.

DeWitt, William D., B.S. in Ae.E., Assoc. Engr., The Glenn L. Martin Co. (Denver).

Dragset, Thomas A., B.S.A.E., Engr., Stress Analysis, Allison Div., General Motors Corp. (Indianapolis).

Dunning, Fred S., Jr., B.S. in Ae.E., Lt., USN; Student, Aero. Engrg. (Tenn.).

Egan, Douglas S., Jr., M.S. in Ae.E., Lt., USAF; Aero. Engr. (Holloman AFB).

Emons, James E., B.S. in Ae.E., Engr., Aerodynamics, North American Aviation, Inc. (Downey).

Fouts, William B., B.S. in Ae.E., Aero. Engr., North American Aviation, Inc. (Downey).

Furno, Rocco A. M., B.A.E., Aerodynamicist, Grumman Aircraft Engineering Corp. (Bethpage).

Gilbert, Thomas W., B.S., Service Engr., Douglas Aircraft Co., Inc. (El Segundo).

Greenberg, Nathaniel F., B. in Ae.E., Engr., Aerodynamics, North American Aviation, Inc. (Los Angeles).

Gurley, David V., B.M.E.A., Assoc. Engr., The Glenn L. Martin Co.

Karawan, Emil B., Assoc. Engr., Northrop Aircraft, Inc.

Knudson, Kenneth E., B.S. in Ae.E., Aero. Research Engr., NACA (Moffett Field).

Hagan, Robert J., B.S.M.E., Assoc. Engr., The Glenn L. Martin Co.

Harper, Homer F., Assoc. Engr., Lockheed Aircraft Corp. (Burbank).

Haynes, Frank E., Jr., B.S., Wind Tunnel Engr., Chance Vought Aircraft, Inc.

Hebeler, Henry K., S.B. in Aero. E., Stress Analyst, Boeing Aircraft Co.

Hixenbaugh, Gale D., B.S., Assoc. Aerodynamics Engr., Convair, San Diego., A Div. of General Dynamics Corp.

Hutcheson, Richard L., B.S., Test Engr., Aero Products.

Jacobson, Paul M., B.S., Jr. Engr. "A," Boeing Airplane Co.

Jones, David J., Jr., B.S., Assoc. Engr., Ryan Aeronautical Co.

Kalb, John F., Jr., B.S., Liaison Officer, USAF (Wright-Patterson AFB).

Kempf, Cecil J., B.S., Lt., USN; Naval Aviator.

King, John E., B.S. in M.E., Assoc. Engr. "A," Douglas Aircraft Co., Inc. (Santa Monica).

Kinneer, Billy L., B.S., Engr., Allison Div., General Motors Corp. (Indianapolis).

Kistler, Ernest L., Jr., B.S. in Ae.E., Aerophysics Engr., Convair, Ft. Worth, A Div. of General Dynamics Corp.

Lebel, Andre L., Stress Engr., Douglas Aircraft Co., Inc. (Santa Monica).

Leng, Jarvis, B.M.E., Research Engr., Grumman Aircraft Engineering Corp.

Long, William R., B.S., Flight Test Engr., General Motors Corp.

Lyman, Earl G., B.S.M.E., Aero. Research Intern, NACA (Moffett Field).

Marhefka, Russell E., B. of Ae.E., Aerodynamicist, The Glenn L. Martin Co.

Mayo, Jack B., B.S., Capt., USAF; Student Test Pilot (Edwards AFB).

McCollough, "J" "B", B.S. in Ae.E., Flight Test Engr., Cessna Aircraft Co.

McQueen, James A., B. of Ae.E., Assoc. Engr., Northrop Aircraft, Inc.

Meyer, Robert J., S.B., Assoc. Engr., Northrop Aircraft, Inc.

Moore, Richard E., B.S., Experimental Engr., Pratt & Whitney Aircraft Div., United Aircraft Corp.

Mulfinger, Robert H., B.S., Engr., Boeing Airplane Co.

Pike, John A., B.S. in Ae.E., Aerodynamicist, Beech Aircraft Corp.

Piper, Robert R., M.S. in Ae.E., Research Asst., The James Forrestal Research Center, Princeton Univ.

Piszkin, Stanley T., Jr., B.S., Assoc. Engr., Convair, San Diego, A Div. of General Dynamics Corp.

Rice, William C., B.S. in M.E., Proj. Engr., USAF (Wright-Patterson AFB).

Roland, Harold E., Jr., B.S. in Ae.E., Major, USMC (Minneapolis).

Sanford, Albert D., B.S. in Ae.E., Research Engr., Rocketdyne Div., North American Aviation, Inc.

Schatz, William J., B.S., Student, California Institute of Technology.

Silver, Hayden J., B.S., 2nd Lt., USAF; Student Officer (Vance AFB).

Skliar, William L., B.S., Capt., USAF; Test Pilot Student (Edwards AFB).

Weiss, Kenneth E., M.S., Lt., USAF; Proj. Engr. (Wright-Patterson AFB).

Westwood, Edward C., B.S., Assoc. Engr., Douglas Aircraft Co., Inc. (Santa Monica).

Wickstrom, Wendell A., Engr., Cessna Aircraft Co.

Wisenbaker, Eugene M., B.S. in Ae.E., Lt., USN; Naval Aviator.

Wood, Ardean E., B.S. in Ae.E., Engr., Boeing Airplane Co.

Changes of Address

Since the Post Office Department does not as a rule forward magazines to forwarding addresses, it is important that the Institute be notified of changes in address 30 days in advance of publishing date to ensure receipt of every issue of the *Journal* and *Review*.

Notices should be printed legibly and sent directly to the Institute of the Aeronautical Sciences, Inc., 2 East 64th Street, New York 21, N. Y.

Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

THIS SECTION reviews important periodicals, technical and research reports, and books received in the IAS Library in order to provide basic documentation for engineers and scientists.

INTERNATIONAL AERONAUTICAL ABSTRACTS, published as an insert in each issue, is an accelerated reviewing service covering worldwide scientific and technical literature. This work is performed by the IAS Staff and is supported by the Air Force Office of Scientific Research of the Air Research and Development Command.

A list of the periodicals and reports series received in the IAS Library is published semiannually, in the January and July issues.

The AERONAUTICAL ENGINEERING INDEX, published since 1947, provides an annual cumulation of the materials reviewed in this section.

THE IAS LIBRARY

Publications reviewed in this section are maintained by the Library for use by the IAS Membership. They are *not* for sale but are made available through the facilities of the Library.

LENDING SERVICES: Institute members, both Individual and Corporate, may borrow periodicals, reports, and books for a period of 2 weeks, excluding time in transit. Excepted are certain reference books and those IAS publications that may be purchased.

PHOTOCOPY SERVICES: The Library is equipped to provide, as a service, positive photocopies of certain materials in its collections. Rates on request.

For detailed information about these and other services, write to:

John J. Glennon, Librarian
Institute of the
Aeronautical Sciences, Inc.
2 East 64th Street
New York 21, New York

PERIODICALS & REPORTS..... 102
INTERNATIONAL AERONAUTICAL ABSTRACTS. 109
BOOKS 163

Subject Index to Periodicals & Reports

Acoustics, Sound, & Noise..... 102
Aerodynamics..... 102
  Aerothermodynamics..... 102
  Boundary Layer..... 102
  Control Surfaces..... 104
  Dynamics of Liquids..... 104
  Fluid Mechanics & Aerodynamic Theory..... 104
  Internal Flow..... 106
  Performance..... 108
  Stability & Control..... 108
  Wings & Airfoils..... 108
Aeroelasticity..... 129
Aeronautics, General..... 132
Airplane Design..... 132
  Air Conditioning & Pressurization.. 134
  Cockpits..... 134
  Fuel Tanks..... 134
  Landing Gear..... 134
  Operation & Performance..... 134
  Windshields..... 134
Airports..... 134
Aviation Medicine
  Human Engineering..... 134
Computers..... 134
Education & Training..... 136
Electronics..... 136
  Amplifiers..... 136
  Antennas..... 136
  Electronic Tubes..... 136
  Magnetic Devices..... 136
  Networks..... 138
  Noise & Interference..... 138
  Oscillators & Signal Generators... 138
  Radar..... 138
  Semiconductors..... 140
Equipment
  Electric..... 140
  Hydraulic & Pneumatic..... 140
Flight Operating Problems..... 140
Flight Testing..... 140
Fuels & Lubricants..... 140
Ice Formation & Prevention..... 140
Instruments..... 140
Laws & Regulations..... 143
Machine Elements..... 143
Maintenance..... 143
Materials..... 143
  Metals & Alloys..... 143
  Metals & Alloys, Nonferrous..... 144
  Nonmetallic Materials..... 144
  Testing..... 144
Mathematics..... 144
Meteorology..... 146
Military Aviation & Armament..... 146
Navigation..... 146
Nuclear Energy..... 146
Parachutes..... 146
Photography..... 146
Physics..... 146
Power Plants..... 148
  Jet & Turbine..... 148
  Ram-Jet & Pulse-Jet..... 151
  Reciprocating..... 151
  Rocket..... 151
Production..... 151
  Metalworking..... 151
  Production Engineering..... 151
  Tooling..... 152
  Welding..... 152
Propellers..... 152
Reference Works..... 152
Rotating Wing Aircraft..... 152
Safety..... 152
Space Travel..... 152
Structures..... 154
  Bars & Rods..... 155
  Beams & Columns..... 155
  Cylinders & Shells..... 155
  Elasticity & Plasticity..... 156
  Plates..... 156
  Sandwich Structures..... 158
  Testing..... 158
  Thermal Stress..... 158
Thermodynamics..... 158
  Combustion..... 158
  Heat Transfer..... 158
VTOL & STOL..... 158
Water-Borne Aircraft..... 160
Wind Tunnels & Research Facilities... 160

Acoustics, Sound, & Noise

Acoustical Materials Problems Posed by Low-Frequency Sound Control. Richard N. Hamme. *Noise Control*, Sept., 1956, pp. 10–15, 62, 63. Discussion of the problems associated with isolation and absorption of noise at low frequencies and of the current techniques for handling them.

The Near Noise Field of Static Jets and Some Model Studies of Devices for Noise Reduction. Leslie W. Lassiter and Harvey H. Hubbard. *U.S., NACA Rep. 1261*, 1956. 12 pp. Supt. of Doc., Wash., $0.20.

New Tools to Lick Aircraft Equipment Noise Problems. B. A. Rose. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 2–6, 1956, Preprint 819.* 12 pp. Description of acoustical research facilities and techniques, including anechoic and transmission-loss chambers, propagation constant, air-acoustical filter, vibration test facilities, and the fuselage acoustical mock-up techniques.

Silencing the Jet Aircraft. Holden W. Withington. *Noise Control*, Sept., 1956, pp. 46–53, 66. Description of the Boeing noise-reduction program, including noise characteristics for a number of model-scale and full-scale nozzles, and preliminary thrust data for some of these configurations. The program incorporates model-scale acoustical and thrust-coefficient tests together with full-scale thrust and 707 Jet Transport prototype noise tests.

Propagation of Sound in Monatomic Gases. *Tech. News Bul.*, Sept., 1956, pp. 121–124. ONR-supported experimental investigation using a modified double-crystal interferometer to obtain measurements in five gases—helium, neon, argon, krypton, and xenon—in order to provide new data on the behavior of gases under nonequilibrium conditions, permitting an intercomparison of propagation theories based on modern kinetic concepts. Includes discussion of translational dispersion and of some of the available sound-propagation theories.

Aerodynamics

Aerodynamic Mixing Downstream from Line Source of Heat in High-Intensity Sound Field. Appendix A, B—Derivation of Equations Appearing in Theoretical Analysis. Appendix C—Flow and Sound Field Measurements. Appendix D—Instantaneous-Temperature Measurements with Resistance Thermometer. Appendix E—Instantaneous-Temperature Measurements with Hot-Wire Anemometer. William R. Mickelsen and Lionel V. Baldwin. *U.S., NACA TN 3760*, Aug., 1956. 75 pp. 13 refs.

On the Motion of a Finite, Towed Cable. J. W. Miles. *Douglas Rep. SM-18593*, Oct., 1954. 23 pp. Derivation in dimensionless form of the equations of motion of a towed cable subject to transverse aerodynamic forces and terminating in a light, high-drag body. Includes analysis by the small-perturbation method of the dynamic motion of the cable with respect to the in-flight equilibrium configuration. Investigation is based on consideration of a towed refueling hose.

Examples of Wave Drag Calculation by Application of Fourier Analysis About a Streamwise Axis. E. W. Graham. *Douglas Rep. SM-19529*, Jan., 1956. 29 pp. 14 refs. Theoretical investigation using Hayes' method for determining the drag of singularities, and applying Fourier analysis both to the singularities distributed in space (representing aircraft components) and to their projections on a streamwise axis, in order to calculate some examples of wave drag.

Aerothermodynamics

Investigation of the Laminar Aerodynamic Heat-Transfer Characteristics of a Hemisphere Cylinder in the Langley 11-Inch Hypersonic Tunnel at a Mach Number of 6.8. Davis H. Crawford and William D. McCauley. *U.S., NACA TN 3706*, July, 1956. 38 pp. 18 refs.

The Laminar Boundary Layer with Variable Fluid Properties. E. R. van Driest. *North American Aviation, Rep. AL-1866*, Jan. 19, 1954. 46 pp. Extension of the Crocco laminar boundary-layer analysis to include variable Prandtl Number. Calculations are presented on skin-friction and heat-transfer coefficients, Reynolds analogy factors, and on recovery for flat plates subjected to a large range of Mach Number.

The Binary-Mixture Boundary Layer Associated with Mass Transfer Cooling at High Speeds. Judson R. Baron. *MIT NSL TR 160*, May, 1956. 280 pp. 80 refs. Theoretical investigation of the laminar boundary-layer flow of a mixture in which a coolant with different physical properties is injected into the primary gas flow. Analysis is based on the equations of change resulting from the Enskog solution of the Boltzmann equation.

Surface-Protection and Cooling Systems for High-Speed Flight. D. J. Masson and Carl Gazley, Jr. (*IAS Natl. Summer Meeting, Los Angeles, June 18–21, 1956, Preprint 368.*) *Aero. Eng. Rev.*, Nov., 1956, pp. 46–55. 13 refs. Discussion of cooling systems for aircraft under transient and continuous heat inputs.

The Effects of Prandtl Number on High-Speed Viscous Flows Over a Flat Plate. Y. H. Kuo. *J. Aero. Sci.*, Nov., 1956, pp. 1,058, 1,059.

Use of the Shock Tube Wall Boundary Layer in Heat Transfer Studies. Robert Bromberg. *Jet Propulsion*, Sept., 1956, pp. 737–740.

Boundary Layer

Equipment Used for Boundary Layer Measurements in Flight. I—The Design and Construction of a Large Multitube Manometer for Use in Flight. II—Two Fixed Head Type Combs for Boundary Layer Investigations. F. M. Burrows. *Coll. of Aeronautics, Cranfield, Rep. 49*, July, 1956. 30 pp.

Su di un Metodo di Soluzione di Problemi di Strato Limite Laminare nei Moti a Simmetria Assiale. Luigi G. Napolitano. *L'Aerotecnica* (Rome), June, 1956, pp. 223–233. 14 refs. In Italian. Derivation of approximate solutions for four cases of axially symmetric boundary layers, based on the von Kármán integral method.

Wind-Tunnel Observations of Boundary-Layer Transition on a Wing at Various

To the ENGINEER of high ability

Through the efforts of engineers The Garrett Corporation has become a leader in many outstanding aircraft component and system fields.

Among them are:

air-conditioning

pressurization

heat transfer

pneumatic valves and controls

electronic computers and controls

turbomachinery

The Garrett Corporation is also applying this engineering skill to the vitally important missile system fields, and has made important advances in prime engine development and in design of turbochargers and other industrial products.

Our engineers work on the very frontiers of present day scientific knowledge. We need your creative talents and offer you the opportunity to progress by making full use of your scientific ability. Positions are now open for aerodynamicists ... mechanical engineers ... mathematicians ... specialists in engineering mechanics ... electrical engineers ... electronics engineers. For further information regarding opportunities in the Los Angeles, Phoenix and New York areas, write today, including a resume of your education and experience. Address Mr. G. D. Bradley

THE GARRETT CORPORATION

9851 So. Sepulveda Blvd.
Los Angeles 45, Calif.

DIVISIONS
AiResearch Manufacturing, Los Angeles
AiResearch Manufacturing, Phoenix
AiResearch Industrial
Rex — Aero Engineering
Airsupply — Air Cruisers
AiResearch Aviation Service

Mobile gas turbine power cart

takes only 30 seconds to start giant B-52 jet engines

The AiResearch MA-1A mobile gas turbine compressor, the first unit of its kind qualified by the Air Force to start the intercontinental B-52 bombers of the Strategic Air Command, is now in volume production at the AiResearch Manufacturing Division of Arizona.

Entirely self-contained, it furnishes a completely automatic source of compressed air power at the point of use. All components, parts and accessories are included in the fully-enclosed weather-proofed trailer.

The mobile unit weighs only 1150 pounds and may be controlled either from the instrument panel or from a remote control panel. It will start and maintain continuous operation at ambient temperatures ranging from −65°F to 130°F, together with the other extremes of environmental conditions encountered at airports throughout the world.

The two-stage gas turbine compressor may be removed easily from its trailer for use in other vehicles or as a stationary unit. It has an output capacity of 120 pounds per minute flow at 50 psia . . . enough power to meet all ground service needs for a modern airplane.

Write to our Sales Planning Department for further information on this product.

Qualified engineers are needed now. Write for information.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Designers and manufacturers of aircraft systems and components: REFRIGERATION SYSTEMS • PNEUMATIC VALVES AND CONTROLS • TEMPERATURE CONTROLS CABIN AIR COMPRESSORS • TURBINE MOTORS • GAS TURBINE ENGINES • CABIN PRESSURE CONTROLS • HEAT TRANSFER EQUIPMENT • ELECTRO-MECHANICAL EQUIPMENT • ELECTRONIC COMPUTERS AND CONTROLS

Angles of Sweepback. A. Anscombe and L. N. Illingworth. *Gt. Brit., ARC R&M 2968* (May, 1952), 1956. 9 pp. BIS, New York, $0.54.

On Transition from Laminar to Turbulent Flow. Francis R. Hama, James D. Long, and John C. Hegarty. *U. Md. Inst. Fluid Dynamics & Appl. Math. TN BN-81 (AFOSR TN 56-381)*, Aug., 1956. 50 pp. 23 refs. Experimental investigation of the flow phenomena associated with boundary-layer transition to obtain qualitative information by means of water-tank observations which permit direct surveillance of the entire flow pattern and which, because of the lower kinematic viscosity of water as compared to air, also allow the use of a lower flow velocity to attain a comparable Reynolds Number in air and make a slow-motion appraisal possible through the expansion of the flow-phenomena time scale inversely proportionate to the kinetic velocity.

L'Interferenza fra Onde d'Urto e Strato Limite. A. Eula. *L'Aerotecnica* (Rome), June, 1956, pp. 177–217. 28 refs. In Italian. Review of the difficulties involved in solving the theoretical problems associated with the interference between shock waves and boundary layer; summary of experimental methods used in the transonic and supersonic regions; and detailed examination of the Ritter-Kuo theoretical method for justifying the observed phenomena.

Characteristics of Turbulence in a Boundary Layer with Zero Pressure Gradient. P. S. Klebanoff. *U.S., NACA Rep. 1247*, 1955. 19 pp. 23 refs. Supt. of Doc., Wash., $0.25. Investigation using a hot-wire anemometer to measure turbulent energy and turbulent shear stress, probability density and flattening factor of u-fluctuation, spectra of turbulent energy and shear stress, and turbulent dissipation.

Influenza in un Vento Laterale Sullo Strato Limite di Corrente Compressibile ad Alta Velocità che Investe un Ostacolo Cilindrico (Ala in Deriva o a Freccia). Aldo Castagno. *L'Aerotecnica* (Rome), June, 1956, pp. 152–159. In Italian. Theoretical investigation of the side-wind influence on the boundary layer on a cylindrical body (yawed- or swept-wing) in a high-speed compressible stream.

Strato Limite Compressibile sul Corpo di Rivoluzione. Dante Cunsolo. *L'Aerotecnica* (Rome), June, 1956, pp. 160–176. 13 refs. In Italian. Discussion of different methods for solving compressible boundary-layer problems, particularly those of bodies of revolution.

Momentum Diffusion from a Slot Jet Into a Moving Secondary. A. S. Weinstein, J. F. Osterle, and W. Forstall. (*ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13–18, 1955.*) *J. Appl. Mech.*, Sept., 1956, pp. 437–443. 11 refs. Results of an experimental impact-tube study of the turbulent, isothermal, incompressible mixing of two streams of the same fluid at different velocities when one stream issues from a slot, correlated by phenomenological considerations.

Control Surfaces

The Determination of Aileron Effectiveness. R. R. Duddy. *Gt. Brit., RAE TN Aero. 2462*, June, 1956. 10 pp. Results of flight tests over a wide range of lift coefficients and at low subsonic Mach Numbers to determine aileron effectiveness derivatives. Comparison is made with wind-tunnel tests and estimates compiled from the RAeS Data Sheets.

More Lift from Better Flaps. *Aircraft* (Canada), Sept., 1956, pp. 45, 47. Discussion of blown flap as applied to a modified de Havilland Sea Venom fighter.

Principes d'Étude de l'Aile à Jet. Maurice Roy. *La Recherche Aéronautique*, July-Aug., 1956, pp. 3–11. In French. Includes definition, experimental methods, and results of the jet flap theory.

Jet-Induced Circulation Control. I. L. Malavard, P. Jousserandot, and Ph. Poisson-Quinton. *Aero Dig.*, Sept., 1956, pp. 21–27. 11 refs.

Dynamics of Liquids

An Equation for Predicting a Mean Drop Size in a High-Speed Spray. D. B. Harmon, Jr. *U. Calif. Pubs. in Eng.*, No. 5, 1955. 13 pp. Derivation of an equation to predict, under specified conditions, the volume-to-surface mean drop size in a high-speed spray issuing from a cylindrical nozzle.

On the Flow of a Viscous Liquid Between Two Co-Axial Circular Cylinders under a Periodic Pressure-Gradient. Lakshmi Sanyal. *J. Technology*, June, 1956, pp. 43–47. Analysis which shows that when the period of the pressure gradient is very small, the motion at each instant is similar to the steady laminar motion under a constant pressure gradient, while, when the period is very large, the motion has a boundary-layer characteristic.

Nomographs Aid Calculation of Pressure Losses in Hydraulic Lines. E. H. Gatwood. *Mach. Des.*, Oct. 4, 1956, pp. 113–118.

Flow in Hydraulic Machinery. A. J. Acosta. *CIT Hydrodynamics Lab. Rep. E-19.11*, Aug., 1956. 6 pp. Outline of overall objectives of a research program performed at the C.I.T. Hydrodynamics Lab., with description of experimental facilities used.

The Effective Viscosity of Suspensions of Spherical Particles. G. J. Kynch. *Proc. Royal Soc. (London), Ser. A*, Sept. 25, 1956, pp. 90–116. Development of a method for solving the hydrodynamic problem involving swarms of particles moving in an incompressible fluid, assuming that the inertia terms in the equation of motion can be neglected.

Fluid Mechanics & Aerodynamic Theory

Fundamental Flow Patterns—A Series of Photographs Illustrating Classical Aeronautical Conditions. F. N. M. Brown. *Aircraft Eng.*, Sept., 1956, pp. 313–17.

Conical Techniques for Incompressible Nonviscous Flow. Homer J. Stewart and Allen I. Ormsbee. *J. Aero. Sci.*, Nov., 1956, pp. 1,029–1,036. Analysis of incompressible potential fields which are homogeneous of order zero. Complex conical velocity functions (U, V, W) are defined whose real parts represent the physical velocity components (u, v, w).

The Rolling-Up of a Vortex Sheet. Marvin Stern. *ZAMP*, July 25, 1956, pp. 326–342. Analysis of the problem of a rolled-up vortex sheet behind a wing of finite span, treating the problem as a two-dimensional time-dependent flow associated with the semi-infinite vortex sheet.

Aerodynamic Investigation of a Parabolic Body of Revolution at Mach Number of 1.92 and Some Effects of an Annular Supersonic Jet Exhausting from the Base. Eugene S. Love. *U.S., NACA TN 3709*, Sept., 1956. 62 pp. 15 refs. Includes: measurements—with the jet inoperative—of lift, drag, pitching moment, radial and longitudinal pressure distributions, and base pressures; and measurements—with the jet in operation—of the pressures over the rear of the body with the primary variables being angle of attack, ratio of jet to free-stream velocity, and ratio of jet to stream pressure.

An Experimental Investigation of Flow over Blunt Nosed Cones at a Mach Number of 5.8. William T. O'Bryant and Reginald M. Machell. *J. Aero. Sci.*, Nov., 1956, pp. 1,054, 1,055. (Also in *GALCIT Memo. 32*, June 15, 1956.) Army-sponsored tests to obtain data on the surface-pressure distribution and the shock-wave pattern. Includes static-pressure measurements and schlieren observations on six models with cone half angles of 10°, 20°, and 40°, and bluntness ratios (the ratio of the radius of the spherical nose to the radius of the base of the model) of 0.4, 0.8, and 1.064 at zero yaw and on two models at angles of yaw of 4° and 8°. Results are compared with predictions of the modified Newtonian approximation.

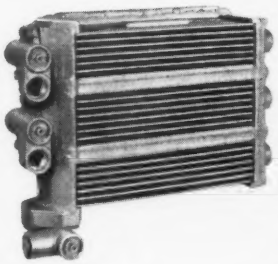
Application de l'Analyse Harmonique au Calcul de Quelques Caractéristiques Géométriques de Contours Plans. G. Fayard. *La Recherche Aéronautique*, July-Aug., 1956, pp. 37–40. In French. Application of harmonic analysis to the calculation of geometric characteristics of aerodynamic profiles.

Über ein Charakteristikenverfahren zur angenäherten Berechnung der unsymmetrischen Überschallströmung um mehrere hintereinander angeordnete ringförmige Körper. Jürgen Zierep. *ZFW*, Sept., 1956, pp. 290–300. In German. Extension of the Haack and Erdmann-Oswatitsch method of characteristics for calculating approximately the asymmetric supersonic flow around a single ring, neglecting the area under the influence of the trailing edge of the ring, in order to derive a solution of the problem of characteristics of the initial value for this area—which originates from the trailing edge of the ring due to the local pressure drop and requires the pressure to be continuous while passing through the surface and the flow vector to lie in a plane tangential to this surface—for the linear terms of the angle of incidence ϑ.

Extremum Principles for Slow Viscous Flow and the Approximate Calculation of Drag. R. Hill and G. Power. *Quart. J. Mech. & Appl. Math.*, Sept., 1956, pp. 313–319. Proof of a complementary pair of extremum principles in their hydrodynamical context and illustration of their application to obtain arbitrarily close approximations from above or below to the total rate of energy dissipation and hence to the drag on a translated or rotated body in the fluid.

Oil's cool on the Vertol H-21 Transport Helicopter with HARRISON on the job!

Fahrenheit's right every flight . . . with Harrison on board! Harrison oil coolers keep vital temperatures in check on transmissions and engines . . . allowing 'copters to fly faster, farther and carry heavier payloads than ever before. These oil coolers are compact, save weight and space. They're specially designed to do the job and do it better. You'll find Harrison handling the heat in every line of industry and defense . . . from hydraulic presses to supersonic jets. That's because every Harrison product is backed by over 46 years' experience in producing top-quality heat-control equipment. If you have a cooling problem, look to Harrison for the answer.



Harrison oil coolers level heat for all kinds of aircraft—from small private planes to intercontinental bombers.

GM GENERAL MOTORS Watch "WIDE, WIDE WORLD" Sundays on NBC-TV

TEMPERATURES MADE TO ORDER

HARRISON

RADIATOR DIVISION, GENERAL MOTORS CORP., LOCKPORT, N.Y.

Axially Symmetric Shapes with Minimum Wave Drag. Max A. Heaslet and Franklyn B. Fuller. *U.S., NACA Rep. 1256*, 1956. 16 pp. 20 refs. Supt. of Doc., Wash., $0.20. Analysis using a quasi-cylindrical theory (i.e., the boundary conditions are applied on the surface of a cylinder rather than on the body itself) for solving the variational problems of the optimum bodies having prescribed volume or caliber. Includes the derivation of a reciprocity relation for axial flow which is used in formulating the variational problems in terms of the drag formula involving geometry, and the formulation of the minimum problems in terms of the combined flow field.

On Supersonic Rotational Flow Behind Strong Shock Waves. II—Flow Past Ogives of Revolution. Appendix I—**Transformation of Crocco's Equation to Polar Coordinates.** Appendix II—**Expansion of Velocity Perturbations u′ and v′.** Appendix III—**The First Approximation Differential Equation.** Abraham Kogan. *Technion Res. Devel. Found., Haifa, TR (AFOSR TN 56-316)*, Jan. 15–July 15, 1956. 35 pp.

Application of Second-Order Shock-Expansion Theory to Several Types of Bodies of Revolution. Robert E. Lavender and Raymond A. Deep. *J. Aero. Sci.*, Nov., 1956, pp. 1,052, 1,053.

An Experimental Study of the One-Dimensional Refraction of a Rarefaction Wave at a Contact Surface. I. J. Billington. *J. Aero. Sci.*, Nov., 1956, pp. 997–1,006. 12 refs.

Interaction of Grids with Traveling Shock Waves. Darshan Singh Dosanjh. *U.S., NACA TN 3680*, Sept., 1956. 81 pp. 27 refs. Theoretical and experimental investigation based on measurements, recorded by means of shadowgraphic and hot-wire techniques, of the emergence, growth, and speeds of the transmitted and reflected shock fronts produced when the incident wave splits after colliding with a grid mounted in the path of traveling shock waves in a shock tube.

Influence d'une Réduction du Débit Capté sur la Résistance Externe d'une Entrée d'Air Supersonique de Révolution. J. Nicolas. *La Recherche Aéronautique*, July-Aug., 1956, pp. 33–36. In French. Analysis of a detached shock wave generated at the supersonic air intake and of the resulting modification of the aerodynamic resistance.

The Accuracy of the Method of Characteristics for Plane Supersonic Flow. M. G. Hall. *Quart. J. Mech. & Appl. Math.*, Sept., 1956, pp. 320–333. Analysis of the mechanism by which errors are propagated through a computation, determination of the effects of various types of errors, and outline of a method for planning computations to achieve specified accuracy with minimum labor.

On Turbulent Flow Near a Wall. E. R. van Driest. (*Heat Transfer & Fluid Mech. Inst. Meeting, Los Angeles, June 23–25, 1955.*) *J. Aero. Sci.*, Nov., 1956, pp. 1,007–1,011, 1,036. Derivation of a theory which provides a continuous velocity and shear distribution for turbulent flow near a smooth wall and which forms the basis for the velocity profiles and resistance owing to roughness or vortex generation.

Internal Flow

The Effects of Dissociation and Ionization on Compressible Couette Flow. H. W. Liepmann and Z. O. Bleviss. *Douglas Rep. SM-19831*, May, 1956. 42 pp. Investigation of the compressible Couette flow for studying the effects of a variation of the gas properties upon recovering temperature, skin friction, and heat transfer, in order to further understand the flow in a high-speed laminar boundary layer.

Der Kraftangriff bei Strahltriebwerken und ihren Verkleidungen. Gerhard Schulz. *ZFW*, Sept., 1956, pp. 285–290. In German. Analysis of the forces acting on a jet engine and its cowling.

Preliminary Measurements of Nonsteady Velocities in a Single Stage Axial-Flow Compressor. Hsuan Yeh, Harry N. Croner, and Donald E. Andrews. *USAF WADC TR 55-249*, June, 1956. 41 pp. 15 refs. Experimental investigation conducted at one operating condition near the design point of the compressor and well to the right of the peak in the head-capacity curve, and with the radial location of all probe points arbitrarily fixed at $4^{3}/_{16}$-in. from the blade tip (roughly near the middle span of the blade) to provide information when the blades are not near stalling. Results are interpreted analytically.

A Detailed Experimental Comparison of Axial Compressor Blades Designed for Free Vortex Flow and Equivalent Untwisted and Twisted Constant Section Blades. S. J. Andrews and H. Ogden. *Gt. Brit., ARC R&M 2928* (July, 1953), 1956. 20 pp. BIS, New York, $0.99.

Subsonic Flow in a Centrifugal Compressor. E. Maillet and J. le Manach. (*A.T.M.A. Conf., Paris, 1955, Paper.*) *Gt Brit., MOS TIL/T4642*, 1956. 24 pp. Translation. Investigation to determine means of improving the performance of a centrifugal compressor with a semiopen rotor. Measurements of mean and pulsating flow are made, principally at the outlet of the rotor and of the diffuser.

How to Select Air Impellers for Optimum Performance. Charles A. Hathaway. *Mach. Des.*, Oct. 4, 1956, pp. 88–95. Method for determining proper type and size of impeller for any given set of applicational requirements.

Effects of Reynolds Number on the Flow of Air Through a Cascade of Compressor Blades. H. G. Rhoden. *Gt. Brit., ARC R&M 2919* (June, 1952), 1956. 34 pp. BIS, New York, $1.62. Investigation of three cascade types for axial-flow compressor blades at camber angles of 20°, 30°, and 40°, respectively. Measurements are made of the distribution of static pressure over the central cross section of the middle blade of each cascade, together with traverses of static pressure, total head, and angle of flow at inlet and outlet to each cascade in the plane of central cross section.

Results of Systematic Investigations on Secondary Flow Losses in Cascades. III—Secondary Flow Losses of a Turbine Cascade for Different Shapes of Blade Tip and Blade Foot. E. G. Feindt. *Braunschweig Tech. Hochschule Inst. Strömungsmech., Rep. 54/32a*, May 15, 1956. 32 pp. In English.

Die Strahlablenkung in der vollbeaufschlagten Turbine. W. Traupel. *ETH Inst. für Thermische Turbomaschinen, Mitteil. No. 3*, 1956, pp. 27–38. In German. Investigation of the occurrence of beam deflection in blading subjected to overcritical pressure drop, showing the development of a correct theory within the limitations of one-dimensional treatment. Results are presented in curve form.

On the Optimum Shape of an Axially Symmetric Diffuser in Compressible Isentropic Flow. M. Z. v. Krzywoblocki. *Istanbul Tek. U., Bul.*, 1956, pp. 103–112. Analytical development of a method for determining the wall contour of axially symmetric diffusers in compressible isentropic flow, assuming that the pressure rise in the diffuser is maximum at the exit.

The Use of Perforated Inlets for Efficient Supersonic Diffusion. John C. Evvard and John W. Blakey. *U.S., NACA TN 3767*, Sept., 1956. 35 pp. Experimental investigation at a Mach Number of 1.85 on a preliminary model of a perforated diffuser having a geometric internal contraction ratio of 1.49 (the isentropic value) and description of the method used.

Der Einfluss der Kompressibilität auf die Druckumsetzung in Verzögerungsgittern. W. Traupel. *ETH Inst. für Thermische Turbomaschinen, Mitteil. No. 3*, 1956, pp. 7–25. In German. Analysis of suitable proportioning and deflection properties of grids in compressible flow which can be reduced to the incompressible case by using the Prandtl law. The Scholz method is taken into account, and the results are presented as diagrams which can be applied to the calculation of decelerated grids at higher Mach Numbers.

Nomograph for Designing Gas Nozzles and Orifices. Eugene Gessner. *Prod. Eng.*, Oct., 1956, pp. 141–143. Presentation of an alignment chart giving weight of flow if the pressure ratio, the upstream pressure, and the orifice diameter are known.

Diagrammes pour le Calcul des Éjecteurs à Flux Moteur Supersonique. E. Le Grivès, J. Fabri, and J. Paulon. *France, ONERA NT 35*, 1956. 27 pp. In French. Presentation of diagrams used for a rapid determination of the ejection characteristics of air-to-air supersonic exhaust nozzles.

Théorie et Expérimentation des Éjecteurs Supersoniques Air-Air. J. Fabri and J. Paulon. *France, ONERA NT 36*, 1956. 25 pp. 11 refs. In French. Results of experimental verification of the theory of air-to-air supersonic exhaust nozzles, taking into account the influence of geometric, aerodynamic, and mechanical parameters.

Tables of Characteristic Slopes for Use in the Design of Nozzles for Supersonic Wind Tunnels. K. G. Winter. *Gt. Brit. RAE TN Aero.2444*, May, 1956. 12 pp.

Die Strömung einer Quellstrecke im Halbraum, eine strenge Lösung der Navier-Stokes-Gleichungen. Curt Schmieden and Karl-Heinz Müller. *ZFW*, Sept., 1956, pp. 300–309. In German. Derivation of an expression for the flow of a line source of constant strength along the z-axis from an exact solution of the Navier-Stokes equations for the upper semispace, and discussion of other solutions, par-

COOL ENOUGH FOR YOU?

Fenwal's new Cooling Effect Detector rides high in North American F-100F Super Sabre . . . Answers question: Is cooling air cool enough?

The Aircraft Industry, the most weight-conscious industry of all, has good news from Fenwal Incorporated — good news in a half-pound package. Fenwal engineers have packed a complete, accurate Cooling Effect Detector into a package that light.

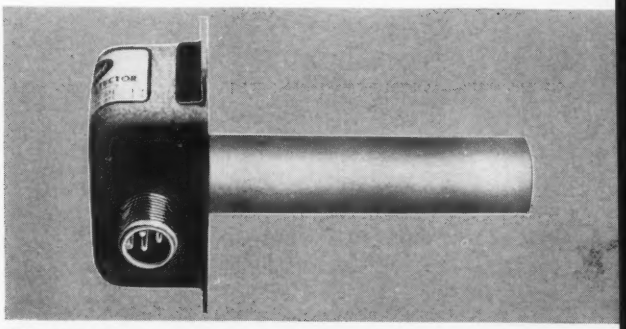
North American has sent the feather-weight detector aloft in the F-100F, where it warns the pilot the instant cooling air for vital electronic equipment fails to cool enough.

The detector, known as the #18801, is not only light but versatile. It can be used wherever cooling air protects vital equipment.

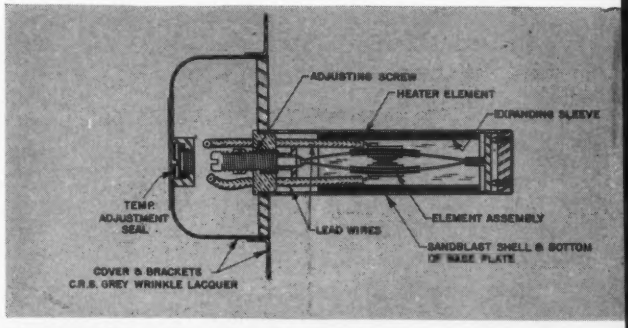
Though simple, it takes into account every variable in air-cooling effect — ambient temperature, air flow, air density, humidity, and others. When the total cooling effect is inadequate, the detector closes a circuit. Depending on the circuitry, an alarm is sounded, an indicator is actuated, or automatic remedial action is taken.

If you are looking for a compact, light detector of inadequate air cooling, the 18801 could easily be your answer. Write for complete data — or, better still, tell us your problem and let us suggest the right answer. **Fenwal Incorporated, Aviation Products Division, 1712 Pleasant St., Ashland, Mass.**

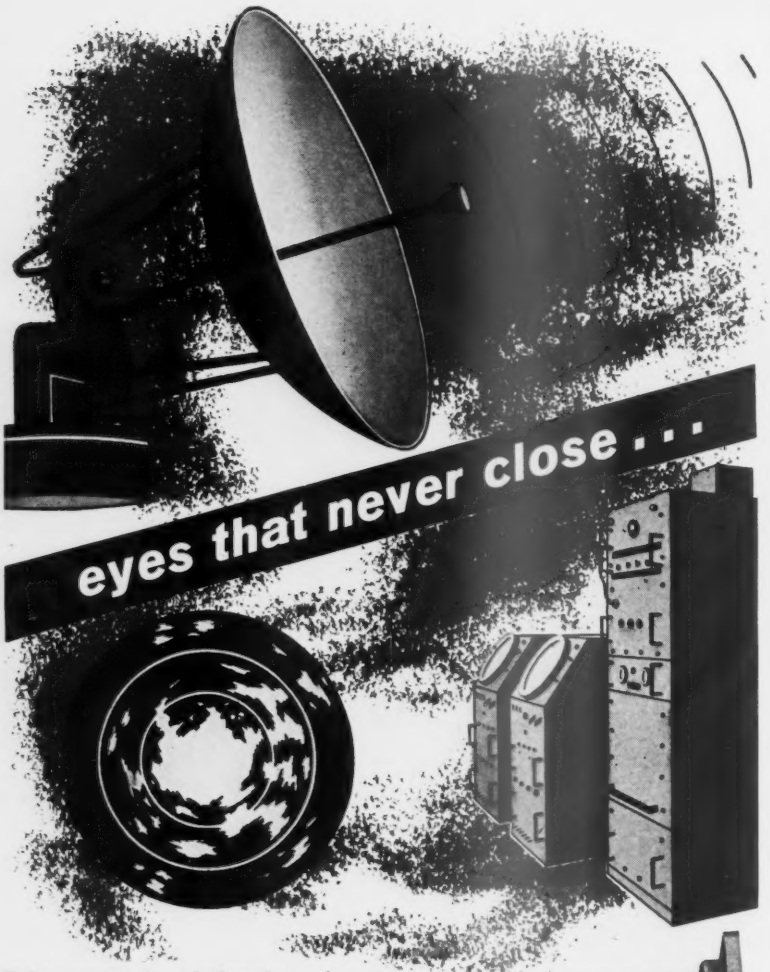
Fenwal Controls Temperature . . . Precisely



ALL IN A HALF-POUND STAINLESS STEEL PACKAGE — here is Fenwal's #18801 Cooling Effect Detector. Inside is a hermetically-sealed THERMOSWITCH® unit with a heater element. Characteristics of a 22 ohm heater element rated at 32 volts D.C. — optimum adjustment range, 500—10,000 lbs./hr./ft² of air flow; exposure limits —65°F to 160°F under "no-flow" conditions. Characteristics vary with other heater element ratings.



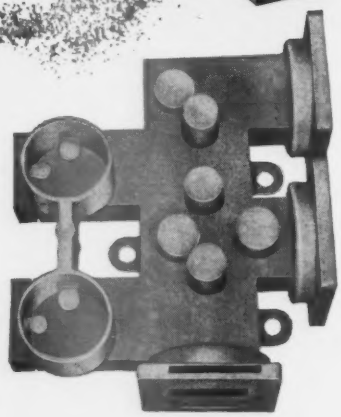
INSIDE STORY — Exposed probe shell is the sensing element. Changes in the rate of heat dissipation cause shell to expand almost at once, actuating internal switch. Switch is surrounded by a heating element. Thus, detector signals its own overheat and, simultaneously, overheat of the protected equipment.



Radar components and other electronic parts must be produced to rigid design specifications and to meet high inspection standards, since part failure may often endanger the lives of the men depending on it for their survival.

ARWOOD Investment Castings simplify design responsibilities, insure dimensional accuracy of complex cored passages and reduce material costs. Reduced weight, greater strength, improved appearance, lower production costs . . . benefits for you when you specify INVESTMENT CASTING!

ARWOOD application engineers are available, without obligation, for consultation in your design and production planning. Contact us when you reach the "blueprint stage" to take advantage of INVESTMENT ECONOMIES.



CASE IN POINT!

Improved performance and reduced production cost, resulted from investment casting this radar mixer body. Previously fabricated from 20 machined components by brazing, waveguide performance was unsatisfactory due to inaccuracy of dimensions and differentials in electrical characteristics. Now made as an integral investment casting, the parts are within dimensional tolerances, the electrical characteristics are uniform, and the cost is 75% less!

ARWOOD PRECISION CASTING CORP.
311 West 44th Street, New York 36, N. Y.
"PIONEERS IN INVESTMENT CASTING"
Plants: Brooklyn, N. Y. • Groton, Conn. • Tilton, N H. • Los Angeles, Calif.

ticularly those which can be expressed in concise form, essentially as the ratio of two polynomials.

Laminar Jet Mixing of Two Compressible Fluids with Heat Release. S. I. Pai. *J. Aero. Sci.*, Nov., 1956, pp. 1,012–1,018. OSR-supported formulation of the problem and discussion of the solution, pointing out the important parameters.

Relazione sui Getti Assialsimmetrici di Gas ad Alta Velocità ed Elevata Temperatura. Lodovico Pascucci. *L'Aerotecnica* (Rome), June, 1956, pp. 234–247. 33 refs. In Italian. Review of investigations of axially symmetric gas jets at high speeds and high temperatures, and classification of these studies according to the assumptions on which they are based. Includes analysis of special cases.

Performance

V-g Records from Vampire Aircraft (March 1951–October 1951). E. Marjorie Owen and J. R. Heath-Smith. *Gt. Brit., ARC R&M 2963* (May, 1952), 1956. 17 pp. BIS, New York, $0.90. Estimation of the V-g boundaries to be exceeded once in 30, 100, and 300 hours, with special consideration for aircraft engaged on ground-attack duties. Results confirm the general belief that more severe accelerations and higher speeds may be expected during ground attack than during the performance of other duties.

Stability & Control

Rotary Stability Derivatives from Distorted Models. D. J. Foster and G. W. Haynes. *J. RAeS*, Sept., 1956, pp. 623, 624.

Comparison of Flight and Wind-Tunnel Measurements of High-Speed-Airplane Stability and Control Characteristics. Walter C. Williams, Hubert M. Drake, and Jack Fischel. *U.S., NACA TN 3859*, Aug., 1956. 16 pp. Evaluation of the accuracy of wind-tunnel tests using data measured in flight on three swept-winged aircraft.

A Wind-Tunnel Test Technique for Measuring the Dynamic Rotary Stability Derivatives at Subsonic and Supersonic Speeds. Benjamin H. Beam. *U.S., NACA Rep. 1258*, 1956. 14 pp. Supt. of Doc., Wash., $0.20.

An Optimum Switching Criterion for a Third-Order Contactor Acceleration Control System. Anthony L. Passera and Ross G. Willoh, Jr. *U.S., NACA TN 3743*, Aug., 1956. 46 pp. Derivation using analytical and analog-computer methods, with results compared to those of a linear system.

Wings & Airfoils

Calculations of the Flow Over an Inclined Flat Plate at Free-Stream Mach Number 1. Walter G. Vincenti, Cleo B. Wagoner, and Newman F. Fisher, Jr. *U.S., NACA TN 3723*, Aug., 1956. 70 pp. 21 refs. Includes determination of the mixed flow about the lower surface of the plate by relaxation solution of the boundary-value problem in the hodograph plane, and description of a method of preliminary analysis required by the presence of the free-stream singularity. The supersonic flow on the upper side of the plate

(*Continued on page 129*)

l
e
s.
f
g
t.
or
xy
ic
t.
a
n-
nd
N
on
er
se
n-
ch
B.
Jr.
pp.
the
the
nd-
aph
re-
nce
er-
ate

INTERNATIONAL AERONAUTICAL ABSTRACTS

A Review of Worldwide Scientific and Technical Literature

Selected and prepared by the IAS Staff from currently released material received in the IAS Library. This research is supported by the Air Force Office of Scientific Research of the Air Research and Development Command. Address inquiries concerning this literature to the IAS Library.

PUBLISHED MONTHLY BY THE AERONAUTICAL ENGINEERING REVIEW
Official Publication of the Institute of the Aeronautical Sciences, 2 East 64th Street, New York 21, N.Y.

Volume 1, Number 12 December, 1956

ACOUSTICS, SOUND, & NOISE

NEAR NOISE FIELD OF A JET-ENGINE EXHAUST. II - CROSS CORRELATION OF SOUND PRESSURES. E. E. Callaghan, W. L. Howes, and W. D. Coles. US, NACA TN 3764, Sept., 1956. 53 pp. Microphone measurements for a range of jet velocities at locations along the jet and at a distance from the jet; longitudinal and lateral free-field correlations of the overall sound pressure and of the sound pressure in frequency bands of 100 to 1000 cps; and correlations with microphones mounted at the surface of a plate that is large compared with the distance over which a positive correlation exists. Results, interpreted in terms of pressure loads on surfaces, indicate that the region of positive correlation increases with distance downstream of the engine to 6.5 nozzle-exit diameters and remains nearly constant thereafter. Little change exists in the correlation curves as a function of jet velocity or frequency bandwidth, and the distance from unity to first zero correlation is greater for lateral than for longitudinal correlations for the same conditions and locations. Correlations are generally similar whether obtained in free space or on the surface of the plate.

AERODYNAMICS

Aerothermodynamics

A SOLUTION OF THE HEAT TRANSFER EQUATION FOR LAMINAR FLOW BETWEEN PARALLEL PLATES. S. C. R. Dennis and G. Poots. Quart. Appl. Math., Oct., 1956, pp. 231-236. Method of solving a two-dimensional heat flow of the Poiseuille type, using the formal Fourier analysis of the type developed by Carslaw and Jaeger. The method is then extended to the more general case where the parameter $u(\eta)$ may be any function satisfying Dirichlet's conditions.

Boundary Layer

K ZADACHE O LAMINARNOM POGRANICHNOM SLOE U PORISTOI STENKI. L. S. Gandin and R. E. Soloveichik. Prikl. Mat. i Mekh., Sept.-Oct., 1956, pp. 663-665. In Russian. Study of the problem of laminar boundary layer along a porous wall. The characteristic feature distinguishing this problem from that of Blasius is that the value of the component velocity in the direction perpendicular to the wall is equal to a given value of W and not to zero. The velocity W and the velocity of the basic flow U is constant and the Shvetz approximate method is used for obtaining a solution.

A TREATMENT OF THE JET FLAP BY THIN-AEROFOIL THEORY. Appendix A - THE PRINCIPAL VALUES OF CERTAIN CAUCHY INTEGRALS. Appendix B - THE PRINCIPAL VALUES OF TWO CONTOUR INTEGRALS. D. A. Spence. Gt. Brit., RAE Rep. Aero. 2568, Nov., 1955. 55 pp. 13 refs. Solutions in Fourier series over a range of jet momentum coefficients for an inviscid incompressible flow past a two-dimensional wing at small angle of incidence, with a trailing edge jet. The jet has zero thickness but finite momentum and emerges at a small deflection to the surface. The flow inside the jet is assumed to be irrotational, and bounded by vortex sheets across which it does not mix with the main stream. Single expressions are obtained for lift, pressure distribution, and pitching moment. Measurements are made on an 8:1 elliptic cylinder with a narrow deflected jet exit close to its trailing edge. The measured lift coefficients are within 5% of the calculated values and the observed centers of lift are within 2% of those calculated over the plate for the whole range of jet-momentum coefficients.

Control Surfaces

THEORY OF AEROFOIL SPOILERS. L. C. Woods. Gt. Brit., ARC R&M 2969, 1956. 21 pp. 12 refs. BIS, New York, $1.08. Development of a mathematical theory for airfoil spoilers in two-dimensional subsonic flow. Equations are given for load distributions, lift, drag, and moments and hinge moments produced by spoiler-flap combinations. A theory is developed for spoilers in a general position and for trailing edge spoilers. The

theory for a trailing edge spoiler shows good agreement with experiment, but in the more general case the agreement is not as good because of the uncertainty about the pressure distribution on the airfoil to the rear of the spoiler.

Fluid Mechanics & Aerodynamic Theory

NEUSTANOVIVSHEESIA DVIZHENIE VIAZKOPLASTICHESKOI ZHIDKOSTI V KRUGLOI TRUBE. Iu. I. Krasil'nikov. Prikl. Mat. i Mekh., Sept.-Oct., 1956, pp. 655-660. In Russian. Study of the nonstationary motion of a viscoelastic fluid in circular tubes, taking into account Gromeka results, and using Genki's differential equations. The viscoelastic media is partly considered as an isotropic elastic body with a given flow limit and partly as an incompressible viscous fluid.

CONVERSION OF INVISCID NORMAL-FORCE COEFFICIENTS IN HELIUM TO EQUIVALENT COEFFICIENTS IN AIR FOR SIMPLE SHAPES AT HYPERSONIC SPEEDS. J. N. Mueller. US, NACA TN 3807, Oct., 1956. 31 pp. Derivation of a simple correlation factor based on shock-expansion calculations for ideal gas conditions and applicable at air Mach Numbers of 12, 16, and 20. Preliminary results indicate that hypersonic helium tunnels may be useful in conventional aerodynamic as well as in fundamental gasdynamic studies.

NEKOTORIE SVOISTVA PROSTRANSTVENNYKH SVERKHZVUKOVYKH TECHENII. M. N. Kogan. Prikl. Mat. i Mekh., Sept.-Oct., 1956, pp. 661, 662. In Russian. Investigation of some characteristics of three-dimensional supersonic flows used for establishing an analogy with plane flows, for obtaining qualitative results, and for simplifying the calculation of flow around given classes of airfoil profiles. A region of turbulent motion, separated from the laminar stream flowing at a supersonic speed V along the axis x by a characteristic surface, is assumed in the region x, y, z.

COMPRESSIBLE VISCOUS FLOW PAST A WEDGE MOVING AT HYPERSONIC SPEEDS. L. J. Pan and Y. H. Kuo. J. Math. & Phys., July, 1956, pp. 179-193. Analysis of a special case of an infinite wedge with large wedge angle, for which a strong shock exists even at infinity, in order to determine the significance of entropy. The investigation is restricted to the weak interaction zone for which an asymptotic solution can easily be found. Results indicate that the contributions due to entropy rise at hypersonic Mach Numbers are small even for the configurations considered, and that the waves reflected by the shock can be neglected at such speeds.

OB ODNOM KLASSE PLOSKIKH I OSESIMMETRICHESKIKH OKOLOZVUKHOVYKH TECHENII. V. N. Zhigulev. Prikl. Mat. i Mekh., Sept.-Oct., 1956, pp. 613-620. In Russian. Derivation of exact solutions of plane near-sonic and axisymmetric flows, taking into account the known plane flows starting from the rectilinear transition line. Plane and axisymmetric flows through nozzles having a break in the generatrix in the point of reaching sonic velocity in the vicinity of the rectilinear transition line are analyzed.

PRESSURE DISTRIBUTION AND DIMENSIONAL DATA ON FREE STREAMLINE SHAPES HAVING WEDGE SHAPED NOSES. Jesse Pierce and A. M. O. Smith. Douglas Rep. ES-17922, June 2, 1955. 60 pp. Information on 73 profiles, each of which has a tail corrected by a curved central portion over which velocity is constant and is symmetrical about its chord line and its 50% chord line. The shapes are developed from ten different wedge angles whose interior angles range from 3° to 210°. It is indicated that the constant velocity portion of the shapes form a nearly affine family for a given wedge angle regardless of the velocity ratio; hence, the resulting curves may be considered "universal turning curves" that illustrate an efficient technique for turning a flow - such as that which exists between two flat panes of glass in an aircraft windshield.

THE IMAGE SYSTEM OF A VORTEX ELEMENT IN A RIGID SPHERE. M. J. Lighthill. Proc. Cambridge Philos. Soc., Apr., 1956, pp. 317-321. Analysis giving the image system of a rigid sphere immersed in an incompressible fluid, the results of which make possible the calculation of secondary flow produced by a three-dimensional obstacle in a sheared stream. The image system is as follows: (a) a transverse vortex element at the inverse point, equal in stregth to minus the transverse resultant of the given vortex element divided by the ratio of its distance from the center to the radius of the sphere; (b) a radial vortex element at the inverse point, equal in strength to plus the radial resultant of the given vortex element, divided by the same ratio; and (c) a uniform line vortex stretching from the inverse point to the center of the sphere, equal and opposite in total strength to the radial vortex element at the inverse point.

MOTION OF A GAS DUE TO A PRESSURE OF SHORT DURATION (SHOCK). Ia. B. Zel'dovich. Soviet Physics - Acoustics, No. 1, 1956, pp. 25-35. Translation. Analysis of the propagation of a plane shock wave and the motion behind the shock front which is created in a gas acted upon by a strong, brief, external pressure, in order to derive laws for the attenuation of the wave and for the distribution of pressure, density, and velocity occurring after the action of the pressure has ceased.

O RESHENII VO VTOROM PRIBLIZHENII ZADACH OSESIMMETRICHNOGO TECHENIIA GAZA. I. M. Iur'ev. Prikl. Mat. i Mekh., Sept.-Oct., 1956, pp. 606-612. In Russian. Analysis of the theory of second approximation used for solving some nonlinear problems and development of a simplified method for calculating supersonic gas flows around ducted bodies of revolution or around contour parts of such bodies not reaching the axis of symmetry.

DIFFRACTION OF DISTURBANCES AROUND A CONVEX RIGHT CORNER WITH APPLICATIONS IN ACOUSTICS AND WING-BODY INTERFERENCE. Lu Ting. Polytech. Inst. Bklyn. Dept. Aero. Eng. & Appl. Mech. PIBAL Rep. 307 (AFOSR TN 56-428) [AD-96510], Aug., 1956. 32 pp. Derivation of an integral equation for finding the pressure disturbance when a given small disturbance passes around a 90° convex corner. The solution is obtained by the method of successive substitution, and this solution and Ting's previously outlined procedure are used to determine the pressure distribution on a rectangular barrier after it is hit by a weak shock. Analysis includes determination of the pressure distribution for a body of square cross section mounted on a semiinfinite wedge.

ELEMENTS OF AN IMPROVED LINEAR PERTURBATION THEORY OF STEADY SUPERSONIC FLOW WITH AXIAL SYMMETRY. C. W. Jones. Proc. Cambridge Philos. Soc., Apr., 1956, pp. 336-343. Method for improving approximations given by the linear perturbation theory of supersonic flow with axial symmetry in order to permit calculations of the flow past less slender bodies than those for which the usual theory is adequate. The new method performs a linear treatment, but leads to explicit integral expressions for the potential and velocity components. A numerical example is given for a 10° cone in a stream of Mach Number 3 and shows that a shock of constant strength may be fitted to the improved solution.

SOME INTEGRATED VOLUME PROPERTIES IN LINEARIZED FLOW AND THEIR CONNECTION WITH DRAG REDUCTION AT SUPERSONIC SPEEDS. Z. O. Bleviss. J. Aero. Sci., Dec., 1956, pp. 1, 078-1, 098. Analysis of the problem of relating the singularity distribution (elements of lift, sideforce, and volume) to the body geometry. The "body" studied is the region between a cylindrical mean surface and the stream surface that coincides with it at upstream infinity, the mean surface being parallel to the free stream and having an arbitrary closed cross section.

Internal Flow

LOW-SPEED WAKE CHARACTERISTICS OF TWO-DIMENSIONAL CASCADE AND ISOLATED AIRFOIL SECTIONS. Seymour Lieblein and W. H. Roudebush. US, NACA TN 3771, Oct., 1956. 49 pp. 18 refs. Calculations giving empirical and theoretical variations with downstream distance of such wake properties as minimum velocity, form factor, momentum thickness, full thickness, and total-pressure loss. Information is also included to corroborate theoretical total-pressure-loss relations presented previously, to convert area-averaged losses to mass-averaged losses, and to indicate downstream variations in air outlet angle. The analysis indicates a general similarity between turbulent cascade and isolated airfoil wake characteristics. The principal result of the analysis is the observation that the reenergizing of the wake downstream of the blade is very rapid. The major part of the mixing loss and the changes in wake characteristics occur within 1/4 to 1/2 chord length behind the trailing edge.

ÜBER DIE DURCHFUHRUNG SYSTEMATISCHER MESSUNGEN AN EBENEN SCHAUFELGITTERN. Norbert Scholz. ZFW, Oct., 1956, pp. 313-333. 24 refs. In German. Derivation of equations for the evaluation of momentum measurements in two-dimensional flow through cascades. Using a correction of general applicability it is possible to convert the computation of the wake flow in a very simple manner. The effect of the jet contraction due to the boundary layer along the side walls is treated using a correction in order to obtain two-dimensional flow characteristics. The equations for the evaluation of the pressure-distribution measurements are also given, and a contribution is made regarding the presentation of test results in the form of nondimensional quantities. Results of systematic measurements of cascades with airfoil sections NACA 0010 are reported.

THE STREAMSURFACE CHARACTERISTICS METHOD FOR SUPERSONIC FLOW, WITH APPLICATION TO SUPERSONIC COMPRESSORS. H. G. Loos. Propulsion Res. Corp. Rep. R-207 (AFOSR TN 56-367) [AD 95803], May, 1956. 98 pp. Analysis of supersonic flows along a curved surface (S) of general but given shape, and with a distance (A) to an infinitesimally adjacent stream surface. Method involves the simplification of the characteristic method for axisymmetric flow by rearranging the analysis in such a way that it refers directly to the flow in the blade surface. Application to the axisymmetric approximation of supersonic flow through a compressor rotor is estimated to give a 30% labor saving compared to Goldstein's method. A simple semi-graphical method is suggested that can be used when S is developable in a plane and no body forces are present.

DOŚWIADCZALNE SPRAWDZENIE ANALITYCZNEJ METODY OBLICZANIA STRAT PRZEPŁYWU PRZEZ PŁASKĄ PALISADĘ PROFILÓW. Wojciech Brzozowski. Arch. Budowy Maszyn (Warsaw), No. 3, 1956, pp. 295-316. In Polish, with summaries in English and Russian. Theoretical investigation of flow losses through a flat cascade of profiles, on the basis of the characteristic parameters of the turbulent boundary layer which forms around the contours of the blades. Formulas are derived to trace the effect of trailing-edge thickness on the efficiency loss in the cascade. The analyzed flow losses are divided into those due to boundary-layer mixing and those due to the eddies formed beyond the trailing edge of the blades. The losses and the range of high-efficiency work for a new type of turbine cascade are calculated, using the new formulas, and compared with experimental data from slow-velocity cascade-tunnel tests.

EXPERIMENTELLER BEITRAG ZUR ENTSTEHUNG TURBULENTER STRÖMUNG IM ROHR. J. Rotta. Ing.-Arch., No. 4, 1956, pp. 258-281. 12 refs. In German. Experimental investigation of the nature of turbulent and laminar state of flow through a tube in order to determine the relation-

ship between relevant dimensions. Intermittency factors are plotted in relation to the Reynolds Number and the effective length for obtaining families of curves for different tube ratios. A theoretical mechanism is suggested for the propagation and development of turbulence from the tube inlet where partial turbulence exists, to complete turbulence, at critical Reynolds Numbers.

ZUR BERECHNUNG DER KRITISCHEN GESCHWINDIGKEIT DER REIBUNGS- UND RELAXATIONSFREIEN THERMOCHEMISCHEN GASSTRÖMUNG DURCH ROHR UND DÜSE. H. Stümke. Ing.-Arch., No. 4, 1956, pp. 282-290. 12 refs. In German. Calculation of the critical velocity of the viscous and relaxation-free thermochemical gas flow through tubes and nozzles, based on the assumption of permanent chemical equilibrium and of the line-flow theory. A comparison is made with the sonic velocity, and it is shown that the critical velocity coincides with the speed of propagation of low-frequency sonic waves with the immediate establishment of equilibrium of the change of state.

Stability & Control

STABILITY DERIVATIVES OF CONES AT SUPERSONIC SPEEDS. Murray Tobak and W. R. Wehrend. US, NACA TN 3788, Sept., 1956. 43 pp. 12 refs. Theoretical investigation, using potential theory for circular cones traveling at supersonic speeds and based on two theoretical techniques applied previously to the case of uniform axial and inclined flow, for calculating stability derivatives due to pitching velocity and vertical acceleration in order to derive closed-form solutions for cones by both methods. In the first method, potential solutions for axial flow and crossflow are derived from the first-order wave equation but in application to calculations for the forces no approximations are made either to the tangency condition or to the isentropic pressure relation. In the second, the first-order crossflow potential and the axial-flow potential are combined correct to a second order. Includes numerical results for the stability derivatives as a function of Mach Number for cones having semivertex angles of 10° and 20° and expressions for the forces, moments, and stability derivatives of arbitrary bodies of revolution obtained by using Newtonian impact theory.

Wings & Airfoils

FINITE SPAN WINGS IN COMPRESSIBLE FLOW. E. A. Krasilshchikova. (Moscow State U., Sci. Rec., Mech. No. 4, 1951; Govt. Pub. House Tech. Theoret. Literature, 1952.) US, NACA TM 1383, Sept., 1956. 130 pp. 27 refs. Translation. Description of an integral equation method for solving the problems associated with slender wings in supersonic flow. A solution to the problem of determining the velocity potential of a wing plan form in unsteady deforming motion is derived for a class of solutions of the wave equation and contains the solution for the two-dimensional problem as a special case. Also derived are a solution in quadratures for the problem of steady supersonic flow over a wing of arbitrary surface and plan form, the effective solution for wings of small span, and formulas for determining the pressure over the wing surface. Illustrative examples are included.

ON THE MEASUREMENT OF SUPERSONIC AEROFOIL DRAG BY PRESSURE TRAVERSE. R. E. Meyer. Australia, ARL Rep. A.97, May, 1956. 30 pp. 12 refs. Determination of the drag in two-dimensional flow in terms of the distributions of static and stagnation pressures along a traverse line downstream of the airfoil. Sources of error are discussed with regard to their effect on the accuracy of drag measurement in small tunnels at medium Mach Numbers.

NORMAL FORCES ON FLAT PLATES IN LOW-DENSITY SUPERSONIC FLOW. D. M. Tellep and L. Talbot. J. Aero. Sci., Dec., 1956, pp. 1,099-1,108. 19 refs. OSR-ONR-sponsored measurements over a range of $200 < Re < 2,400$ and $3.7 < M < 4.1$ at angles of attack up to eight degrees, with a series of models having an aspect ratio range from 1.0 to 2.0. Results are compared to the linearized inviscid theory, and indicate that normal forces are 33% to 77% greater than values predicted by theory, the experimental normal forces decreasing with increasing Reynolds Number. The decrease in normal force with decreasing aspect ratios is found to be from 3% to 7% greater in magnitude than predicted by inviscid theory and substantially independent of the Reynolds Number over the range tested. Weak interaction theory is used to derive a simple expression for the normal force and to predict the order of magnitude of the increased normal force as well as the trend of the normal force with the Reynolds Number.

AN ASSESSMENT OF BODY LIFT CONTRIBUTIONS AND OF LINEARIZED THEORY FOR SOME PARTICULAR WING-BODY CONFIGURATIONS. J. W. Reyn and J. H. Clarke. Polytech. Inst. Bklyn. Dept. Aero. Eng. & Appl. Mech., PIBAL Rep. 305 (AFOSR TN 56-429) [AD-96511], June, 1956. 70 pp. 10 refs. Theoretical investigation of a configuration composed of a circular half cone mounted beneath a swept wing of zero thickness, with comparison (at equal lift coefficient and Mach Number) of the drag of the configuration to that of three other configurations. Numerical calculations are carried out for the supersonic flow fields around cones and cone cylinders at zero angle of attack. The purpose of the inquiry is two-fold: to determine if the lift induced by the cone in supersonic flow into the configuration analyzed is capable of providing significant reductions in the pressure drag at practical values of the lift coefficient; and to evaluate the accuracy of linear theory in wing-body interference problems. The models used for comparison in the configuration analysis include the inverted counterpart of the original model, a configuration composed of the same wing and a symmetrically disposed cone with equal volume, and the wing alone.

AEROELASTICITY

ON THE VIBRATION OF A CIRCULAR MEMBRANE WITH ADDED MASS. Hirsh Cohen and

George Handelman. Rensselaer Polytech. Inst. Dept. Math., Rep. 1 (AFOSR TN 56-403) [AD 96211], July 31, 1956. 16 pp. Theoretical investigation of the characteristic frequencies of a circular membrane carrying a rigidly attached concentric circular mass of finite area and vibrating symmetrically, in order to determine the ranges of the parameters for which the frequencies will always be above or always be below those of the unloaded case. Analysis uses the appropriate minimum principle, and obtains the first term in the asymptotic expansion of the higher frequencies. Results indicate that the frequency may be raised or lowered by the addition of distributed mass.

VOPROSY OBSHCHEI TEORII UPRUGOI USTOICHIVOSTI. V. V. Bolotin. Prikl. Mat. i Mekh., Sept.-Oct., 1956, pp. 561-577. 24 refs. In Russian. Survey of investigations of the general theory of elastic deformations and analysis of the stability problem of given equilibrium configuration in arbitrarily elastic bodies, based on the general equations of the theory of end deformations.

OB USTOICHIVOSTI VRASHCHENIIA TVERDOGO TELA, PODVESHENNOGO NA STRUNE. E. P. Morozova. Prikl. Mat. i Mekh., Sept.-Oct., 1956, pp. 621-626. In Russian. Investigation of the rotary stability of solid bodies suspended by a string and assumed to be absolutely elastic and not subject to torsion. The simplified scheme of the mechanical system is analyzed, neglecting the drag forces. The system is holonomous and has five degrees of freedom.

EFFECT OF STRUCTURAL FLEXIBILITY ON AIRCRAFT LOADING. XIII - VERTICAL TAIL MANEUVERING LOADS WITHOUT BANKING DEGREE OF FREEDOM. Appendix A - CONVENTIONS. Appendix B - DEVELOPMENT OF AERODYNAMIC DEFORMATION EQUATIONS. Appendix C - DEVELOPMENT OF INERTIAL DEFORMATION EQUATIONS. Appendix D. J. F. McCarthy, Jr., and A. A. Kirsch. USAF WADC TR 6358, Nov., 1953. 73 pp. 23 refs. Analysis for determining effects of structural flexibility on vertical tail loads, considering only sideslip and yaw and neglecting the rigid body angle-of-bank degree of freedom. Calculations are made for a typical fighter and banker for different maneuvers.

INITIAL RESULTS OF A FLIGHT INVESTIGATION OF THE WING AND TAIL LOADS ON AN AIRPLANE EQUIPPED WITH A VANE-CONTROLLED GUST-ALLEVIATION SYSTEM. T. V. Cooney and R. L. Schott. US, NACA TN 3746, Sept., 1956. 31 pp. Preliminary evaluation of the gust-alleviation-system effectiveness, derived from a sample of measurements obtained in flight through clear-air turbulence with the control system on and off. The control system used incorporates a vane which senses changes in angle of attack produced by gusts and causes the trailing-edge flaps and ailerons to deflect in order to counteract lift; the elevator is split and the outer parts are geared to the flaps in order to balance pitching moment. Results, which point out both the advantages and disadvantages of the system, indicate that a reduction of 43% in root-mean-square normal acceleration at the airplane c.g. has been achieved. Measurements of wing and horizontal-tail aerodynamic loads obtained in a pull-up maneuver in smooth air with the system on and off are also presented.

A SIMPLIFIED TREATMENT OF A FIXED-ROOT SWEPT WING BUILT ON HILL'S ISOCLINIC PRINCIPLE. D. Williams. Gt. Brit., ARC R&M 2870, 1956. 15 pp. BIS, New York, $0.81. Analysis of the aeroelastic behavior of an isoclinic swept wing having straight flexural and inertia axes. Simplification of the analysis is emphasized by omitting damping terms from the equations of motion. Results indicate that the further aft the flexural axis from the quarter-chord position the smaller is the sacrifice of the wing torsional stiffness entailed in making a swept wing isoclinic. Previous work has a far-aft position taken into account as a reasonable basic assumption, with the result showing that to avoid aeroelastic instability a well-forward position for the inertia axis is arrived at. It is shown, however, that by still further sacrifice of torsional stiffness it is possible to reduce considerably the gap between the two axes and to simplify one aspect of the constructional problem.

A STUDY OF THE MEANS OF IMPROVING UNSTEADY AERODYNAMIC DERIVATIVES. Appendix - SUBSONIC AERODYNAMIC INFLUENCE COEFFICIENTS. Arnold Lee and Simon Slutsky. Lee Arnold Assoc., Rep. 56-1, Jan., 1956. 58 pp. 12 refs. Analysis of existing experimental data and examination, using available theoretical and experimental results, of the effect of varying the assumptions on which theoretical aerodynamic derivations are usually based, in order to determine more reliable unsteady aerodynamic derivatives. Consideration is also given to some possible means of improving and correcting theoretical aerodynamic derivatives by adjusting theoretical aerodynamic-influence coefficients through the appropriate use of experimentally determined coefficients.

WIND TUNNEL TESTS ON ANTISYMMETRIC FLUTTER OF A DELTA WING WITH ROLLING BODY FREEDOM. D. R. Gaukroger and D. Nixon. Gt. Brit., ARC CP 259, 1956. 9 pp. BIS, New York, $0.36. Investigation of the effect of fuselage rolling moment of inertia on critical flutter speed and frequency. The model has a leading edge sweepback of 45° and a tip chord of 1/16th of the root chord. The results show that body freedom flutter is obtained under conditions of fuselage rolling moment of inertia that are representative of full scale. The flutter speeds are considerably higher, and the frequencies lower than those with the root fixed. With large values of fuselage rolling moment of inertia disturbed root flutter occurs, the speeds being higher than with the root fixed.

A WIND-TUNNEL TECHNIQUE FOR FLUTTER INVESTIGATIONS ON SWEPT WINGS WITH BODY FREEDOMS. P. F. Jordan and F. Smith. Gt. Brit., ARC R&M 2893, 1955. 11 pp. BIS, New York, $0.63. Description of a method which in-

volves the use of a half-span model to avoid the confusion entailed in the simultaneous occurrence of symmetric and antisymmetric flutter and in which the boundary conditions artificially introduced at the plane of symmetry can be adapted without loss of realism to produce at any one time either type of flutter and to exclude the other. The half-span wing model is attached to a rigid body; longitudinal stability is ensured; and the body mass parameters are reduced to small values by an appropriate arrangement of supporting springs. The ease of parameter variations makes the wind-tunnel rig suitable for systematic investigations, particularly with respect to tailless aircraft with swept wings.

SPECTRAL THEORY OF BUFFETING AND GUST RESPONSE: UNIFICATION AND EXTENSION. H. S. Ribner. J. Aero. Sci., Dec., 1956, pp. 1,075-1,118. Analysis using the statistical approach to the dynamic response of aircraft in turbulent air. The basic element is the response of the airplane to flight through an inclined sinusoidal upwash pattern in three-, two-, and one-dimensional case. The three-dimensional case is treated in a general manner, the two-dimensional case is idealized as a lifting surface or a lifting line, and the one-dimensional case as a lifting point. Liepmann results are used in the cases of a lifting line and a lifting point. An extension of the case of a lifting line is made for the sweptback lifting line, and an extension of the case of a lifting point to provide rolling moments due to spanwise upwash gradients.

CALCULATION OF THE FORCES AND MOMENTS ON A SLENDER FUSELAGE AND VERTICAL FIN PENETRATING LATERAL GUSTS. J. M. Eggleston. US, NACA TN 3805, Oct., 1956. 20 pp. Derivation of a theory based on slender-body theory and applicable to both subsonic and supersonic airspeeds, provided the local flow angles between the profile and the airstream are small. Results indicate that the force of any element along the length of a slender body (or flat plate) penetrating a gust depends only on the body shape, the rate of change of that shape, and the local flow angle; but that, when the same distribution of local flow angle is obtained by bending of the body, the force on the body depends both on these same functions and on the rate of change of local flow angle along the length of the body.

AN INVESTIGATION OF THE LOADS ON THE VERTICAL TAIL OF A JET-BOMBER AIRPLANE RESULTING FROM FLIGHT THROUGH ROUGH AIR. Jack Funk and R. H. Rhyne. US, NACA TN 3741, Oct., 1956. 36 pp. 12 refs. Experimental investigation with results compared to those obtained from discrete-load calculations and from calculations based on power spectral analysis. Test results reveal large and regular slightly damped load oscillations and, checked against the theoretical predictions, indicate that discrete-gust calculations for gust loads on vertical tails seriously underestimate the gust loads for airplanes having lightly damped lateral oscillations. Power-spectral calculations are shown to reflect the general frequency characteristics of the measured loads and to provide a more accurate estimate of the tail loads.

AIRPLANE DESIGN

Cockpits

DESIGN, FABRICATION AND TEST OF LAMINATED PANED CANOPY SECTION. M. C. Wardle. USAF WADC TR 54-395, May, 1954. 68 pp. Experimental investigation of a specimen section, two panels long by two panels wide, under standard conditions for hot-soak, cold-soak, ambient-pressure, and pressure-cycling tests. The canopy frame is constructed of orlon-methacrylate laminate, which has thermal characteristics approximating those of the transparent pane material. The laminated panes, whose interlayer is reinforced to a width of 1/2-in. from each edge with orlon-methacrylate laminate and cemented into place with methacrylate cement, can readily be removed with standard shop tools; replacement panes can be attached.

Ejection Seats

EJECTION FROM HIGH SPEED AIRCRAFT. James Martin. J. RAeS, Oct., 1956, pp. 659-668. Review of the ejection seat development indicating the physiological considerations influencing the design, and outlining various tests necessary for perfecting the standard seat. Descriptions are given of the automatic ejection seat, the time release, ejection guns, leg restraining harness, and the duplex drogue. Escape conditions are outlined for low-level, high-level, and high-speed ejection; and such future developments as downward and pod ejection are discussed.

Landing Gear

BAND-PASS SHOCK AND VIBRATION ABSORBERS FOR APPLICATION TO AIRCRAFT LANDING GEAR. Appendix - SIMPLIFIED EQUATIONS OF MOTION FOR LOW-PASS SHOCK STRUT. Emanuel Schnitzer. US, NACA TN 3803, Oct., 1956. 27 pp. Description of designs which overcome some of the problems associated with the landing and taxiing of high-speed aircraft on rough land or water runways, and discussion on the operation of the band-pass shock absorbers in the reduction of loads in certain selected frequency ranges. Solutions are developed for several cases in order to provide a basis for comparison between the low-pass and conventional shock-absorber actions. Analytical results indicate that band-pass should alleviate high-frequency or rapidly applied impact loads, but should retain the characteristics of conventional oleo struts when taxiing and design landing loads are applied slowly.

THE INFLUENCE OF ROPE STRETCH ON TENSION VARIATIONS IN ARRESTING GEARS. N. I. Bullen. Gt. Brit., ARC R&M 2964, 1956. 38 pp. BIS, New York, $1.80. Description of a method for determining the performance of an arresting gear as a whole without assuming the conventional hypothesis of an inextensible rope. The results, compared to actual values obtained from a gear, are applicable to the tension oscillations occurring in practice. Calculations are made for a constant-pressure type arresting gear and the tensile oscillations are shown to be interrelated with the action of the constant-pressure valve and the general hy-

draulic system. The calculations are repeated for an inextensible rope with the same gear and the effect of rope stretch is indicated.

COMPUTERS

TRIDAC - A RESEARCH FLIGHT SIMULATOR. I, II. J.J. Gait and J.C. Nutter. Electronic Eng., Sept., Oct., 1956, pp. 368-372, 430-433. Description of the RAE large tri-dimensional computer, with discussion of its basic computing elements and unique features, and a detailed analysis of the three approaches to the axis transformation problem in terms of the machine's requirements. Includes description of the three monitoring systems used and a speculation on the capabilities of future computers The three axis-transformation systems - the direct-cosine, the gimbal (or flight-table), and the synthetic-gimbal - are evaluated for illustrating the reasons for the selection of the synthetic-gimbal technique for Tridac. The monitoring systems detect all of the probable faults in the amplifier circuits, warn of failure in the drift-stabilization system which could lead to increased voltage at this critical point, and guard against overloading of signal levels in input and output.

ELECTRONICS

ON A METHOD FOR OPTIMIZATION OF TIME-VARYING LINEAR SYSTEMS WITH NONSTATIONARY INPUTS. Marvin Shinbrot. US, NACA TN 3791, Sept., 1956. 39 pp. Description of a new procedure for solving integral equations which depends on the correlation functions being of a certain type that is, coincidentally, found in a large number of practical problems. Includes examples to illustrate techniques for determining the differential equations of the optimum system from the impulse response, and an explanation of the concept of a time-varying transfer function.

PORTÉE DES LIAISONS DE TÉLÉCOMMUNICATION EN U.H.F. (225 À 400 Mc/s). S. Zisler. Docaéro, May, 1956, pp. 29-40. In French. Study of UHF telecommunication systems, covering the interference zone, the diffraction correction, and such parameters as the emitting and receiving power, antenna size, and ground contour. Included are the effect of the reflection from the ground, intercommunication between the ground and an aircraft at high altitude, the influence of the aircraft altitude and of the antenna height, and advantages of the directional antenna.

EQUIPMENT

Electric

PUISSANCE DES MACHINES ÉLECTRIQUES EN ALTITUDE; MACHINES AUTOVENTILÉES - MACHINES SOUFFLÉES. A. Sageau. Docaéro, Jan., 1956, pp. 15-28. In French. Calculation of thermal quantities involved in normal operation and at increased speed and altitude for auto-ventilated and ancillary-cooling systems. A criterion of efficient refrigeration is established, assuming a maximum temperature of 363°K. The results are analyzed in relation to design, load imposed on the aircraft, and the possibility of satisfactory functioning at altitudes of 15 to 20 km. and speed of the order of M = 1.5.

FUELS & LUBRICANTS

THEORETICAL PERFORMANCE OF JP-4 FUEL AND LIQUID OXYGEN AS A ROCKET PROPELLANT. II - EQUILIBRIUM COMPOSITION. V. N. Huff, Anthony Fortini and Sanford Gordon. US, NACA RM E56D23, Sept. 7, 1956. 47 pp. 15 refs. Calculation of theoretical rocket performance for an equilibrium composition of fuel during expansion, performed at two chamber pressures and with several pressure ratios and oxidant-fuel ratios. Parameters included are specific impulse, combustion-chamber temperature, nozzle-exit temperature, molecular weight, molecular weight derivative, characteristic velocity, coefficient of thrust, ratio of nozzle-exit area to throat area, specific heat at constant pressure, isentropic exponent, viscosity, and thermal conductivity. A correlation is given for the effect of chamber pressure on several of the parameters.

INSTRUMENTS

Automatic Control

PRIMENENIE OPERATSII D-RAZBIENIIA DLIA POSTROENIIA KORNEVYKH KHARAKTERISTIK I ISSLEDOVANIIA KACHESTVA SISTEM AVTOMATICHESKOGO REGULIROVANIIA. Iu. A. Gopp. Avtomatika & Telemekhanika, Sept., 1956, pp. 789-798. 14 refs. In Russian. Application of D-decomposition to curve family plotting, when the curves are the depiction of lines parallel to the imaginary axis. The root loci, assumed to be the curve variation of real and imaginary roots of a characteristic equation in varied parameters function, are calculated. The optimum parameters providing the desired quality of transient process are also determined.

K ZADACHE OB AVTOKOLEBANIIAKH V SISTEMAKH AVTOMATICHESKOGO REGULIROVANIIA S DVUMIA SERVOMOTORAMI POSTOIANNOI SKOROSTI. V. A. Troitskii. Prikl. Mat. i Mekh., Sept.-Oct., 1956, pp. 627-638. In Russian. Derivation of an exact solution to the problem of autovibration in automatic-control systems, with two control members having two servomotors of "yes-no" type, in the case when multiple roots are included in characteristic equations of the linear part of the system.

Flow Measuring Devices

WIND-TUNNEL CALIBRATION OF A COMBINED PITOT-STATIC TUBE AND VANE-TYPE FLOW-ANGULARITY INDICATOR AT MACH NUMBERS OF 1.61 AND 2.01. A. R. Sinclair and W. D. Mace. US, NACA TN 3808, Oct., 1956. 11 pp. Results of tests on a flow-angularity indicator for research aircraft. It is shown that the instrument registers too high an angle of attack and gives an error of 0.7° at an angle of attack of 20° for a Mach Number of 1.61, and an error of 1.6° at an angle of attack of 24° for a Mach Number of 2.01. At zero angle of

attack the flow field about the yaw vane is unsymmetrical and causes an error of 1.4° in yaw at the zero angle of yaw for a Mach Number of 2.01. The installation of a dummy vane pedestal to provide a more symmetrical flow field reduces this error to 0.25°.

MACHINE ELEMENTS

Bearings

EFFECT OF THREE DESIGN PARAMETERS ON THE OPERATING CHARACTERISTICS OF 75-MILLIMETER-BORE CYLINDRICAL ROLLER BEARINGS AT HIGH SPEEDS. Appendix A, B - DERIVATION OF MAXIMUM ROLLER SKEW ANGLE AS A FUNCTION OF ROLLER AXIAL CLEARANCE RATIO. W. J. Anderson. US, NACA TN 3772, Oct., 1956. 37 pp. 15 refs. Three experimental investigations to determine the effects of (a) roller axial clearance ratio, (b) cage diametral clearance ratio, and (c) cage land (locating surface) width-diameter ratio on bearing operating temperatures, wear, cage slip, and high-speed operating characteristics.

Seals

DEVELOPMENT OF HIGH-LOW TEMPERATURE AIRCRAFT CANOPY SEALS. I - NEW MATERIAL SEALS OF CURRENT DESIGN. J. S. Islinger. USAF WADC TN 55-441, June, 1956. 44 pp. Evaluation of silicone rubber seals for high-low temperature pressure and rain seals. Three seal designs considered are representative of diaphragm, inflatable, and noninflatable types. The seals are tested at temperatures ranging from -85°F. to + 200°F., and subjected to 25 open-close pressure cycles at -65°F. and 1,000 open-close cycles at room temperature. The inflatable seal generally appears more effective than the noninflatable one in sealing the canopy fixture against a maximum differential pressure of 12 psi. All designs are capable of preventing moisture from entering the cockpit. The diaphragm seal is not evaluated because satisfactory installation could not be obtained.

MATERIALS

Metals & Alloys, Nonferrous

SOME OBSERVATIONS ON THE RELATIONSHIP BETWEEN FATIGUE AND INTERNAL FRICTION. S. R. Valluri. US, NACA TN 3755, Sept., 1956. 42 pp. Experimental investigation, using an especially designed torsional fatigue-testing machine of the resonant type with facilities for measuring internal friction at low stress levels, for determining the internal friction and fatigue strength of commercially pure 1100 aluminum under repeated stressing in torsion at various temperature and stress levels in an effort to detect any possible connection between internal friction and fatigue characteristics. Results indicate the existence of a critical temperature at which the fatigue life of specimens appears to reach a minimum value and which has a substantial effect on the internal friction at various stress levels. Further, a discussion of the phenomenon of the recovery of internal friction during brief rest periods culminates in the observation that such recovery depends on the stress level and temperature of testing.

PROBLEMS ASSOCIATED WITH THE PRODUCTION AND USE OF WROUGHT ALUMINIUM ALLOYS. G. Forrest and K. Gunn. J. RAeS, Oct., 1956, pp. 635-654; Discussion, pp. 654-657; Author's reply, pp. 657, 658. 24 refs. Discussion of the properties required in order to keep wrought aluminum free from residual stresses that might distort it when machined; and indication of the effect of each stage of production on these properties. Remelting and alloying, casting, extruding, rolling, forging, heat treating, and stretching stages are discussed in these terms. Inspection procedures for flow detection are outlined. The effects of production variables on tensile and fatigue properties, bending and forming, and stress corrosion are examined and data illustrating test results are presented.

Nonmetallic Materials

LE FLUAGE DES PLASTIQUES ET MATÉRIAUX DÉRIVÉS. G. Fabre. Docaéro, Jan., 1956, pp. 39-52. 52 refs. In French. Survey of several aspects of creep in plastics and derived materials, including its initial appearance, the effect on fabricated structures, limitations of rational definition, and methods of testing. Results are presented for perspex, polystyrene, and laminates, and the influence of molecular structure is shown graphically.

Testing

DETERMINATION OF DYNAMIC PLASTIC STRAIN THROUGH THE USE OF DIFFRACTION GRATINGS. J. F. Bell. J. Appl. Phys., Oct., 1956, pp. 1,109-1,113. Experimental method for obtaining either the dynamic or static strain by measuring the angle of diffraction of a grating on the specimen's surface which changes as the result of a change in the number of lines per inch in the grating caused by strains in the specimen. It is shown that best results are achieved with a 1/32-in. gage length and that blazed reflection gratings ruled directly on the specimen surface yield better data for large strain than bonded replica gratings. Experimental results in A2S0 aluminum specimens are given for the case of an impact produced by a 10-lb. mass at a velocity of 63 ft./sec., and compared with those obtained from the slopes of the static stress-strain curve, assuming a constant velocity impact.

MATHEMATICS

COMPLEX VECTOR BUNDLES OVER AN ALGEBRAIC CURVE. Shigeo Nakano. Inst. Advanced Study, Princeton, N.Y. (AFOSR TN 56-432) [AD 96515], July, 1956. 40 pp. 12 refs. Development of a method using Chow's coordinates of graphs from an algebraic curve to obtain a Grassmannian variety for algebraic parametrization of a set of vector bundles over an algebraic curve. An analytical version of the classification theorem for vector bundles is given. Atiyah's proof is also given for the theorem

which states that bundles in a set can be realized by mapping from an algebraic curve into one and the same Grassmannian variety.

NEW ISOPERIMETRIC INEQUALITIES FOR EIGENVALUES AND OTHER PHYSICAL QUANTITIES. L. E. Payne. Commun. on Pure & Appl. Math., Aug., 1956, pp. 531-542. 29 refs. USAF-supported derivation of new inequalities for the eigenvalues of certain classical plate and membrane problems, and consideration of the Stekloff problem in an infinite three-dimensional region which lies exterior to a closed surface. The Pólya-Szegö definition of the term "isoperimetric inequality" is used. The derivation is based on the assumption that the displacement satisfies a certain differential equation in a plane domain with boundary in the x, y-plane. Results of the Stekloff-problem analysis yield the isoperimetric inequalities for the first and second eigenvalues.

UPPER AND LOWER BOUNDS FOR EIGENVALUES BY FINITE DIFFERENCE METHODS. H. F. Weinberger. Commun. on Pure & Appl. Math., Aug., 1956, pp. 613-623. OSR-supported analysis for estimating the minimum of the ratio of two quadratic functionals corresponding to certain differential operators on a finite region R. A procedure is described for finding a lower bound for the minimum by means of Weinberger's difference method: the upper bound is obtained from a finite difference problem on a grid that is smaller than or equal to R; the lower bound by a problem on a grid that is slightly larger. Hersch's method is also described and improved.

UNDERPOLYNOMIALS AND INFRAPOLYNOMIALS. T. S. Motzkin and J. L. Walsh. Harvard U., Math. Div. TR (AFOSR TN 56-359) [AD-95445], July 31, 1956. 32 pp. Investigation of the properties of a class of infrapolynomials of given degree on a bounded set. Discussion includes proof that the class of infrapolynomials on a closed bounded set (E) is close and connected. Special properties are studied, and the finite generation of such polynomials is shown. Convexity of the class is proved whenever it exists, and factorization is discussed. Infrapolynomials on a real set have special properties of separation, analogous to those previously established for a finite set. The finite generation of real sets is also described.

ON SINGULAR AND REGULAR CAUCHY PROBLEMS. J. B. Diaz. Commun. on Pure & Appl. Math., Aug., 1956, pp. 383-390. 14 refs. OSR-supported consideration of (1) the singular problem for the Euler-Poisson-Darboux equation, (2) the singular problem for a generalization of this equation in two space variables, and (3) a regular problem for the same equation.

A NOTE ON AUTONOMOUS SECOND ORDER NON-LINEAR DIFFERENTIAL EQUATIONS. W. R. Utz. Mo. U., Dept. Math., TN 8 (AFOSR TN 56-420), Sept., 1956. 12 pp. Analysis using theorems on the boundedness of solutions of second-order nonlinear differential equations as a basis for more detailed examination of the behavior of such equations solved for large values of the independent variable. The theorems cited give sufficient conditions for the existence of constants A, B > O such that if x = x(t) is a solution of the given equation valid for all large t, then x (t) < B is a solution for all t > A where A and B may depend upon the particular solutions x = x(t).

ON APPROXIMATION BY BOUNDED ANALYTIC FUNCTIONS. J. L. Walsh. Harward U., Math. Div., Rep. (AFOSR TN 56-440) [AD-96783], Sept., 1956. 30 pp. 13 refs. OSR-sponsored analysis of Problem 3 based on the Walsh theorem pertaining to the conformal mapping of multiply connected regions, and on suitable refinements of older methods. Includes an approximation of a function f (z) analytic in a region D bounded by Jordan curves on a portion B of the boundary of D by functions $f_n(z)$ analytic and in modulus not greater than M_n in D, as well as an investigation of convergence on B in terms of M_n, depending on regions of analyticity of f (z) and on the continuity properties (Lipschitz conditions) of f (z) on the boundaries of such regions.

ON THE REFLECTION PRINCIPLE FOR POLYHARMONIC FUNCTIONS. Alfred Huber. Commun. on Pure & Appl. Math., Aug., 1956, pp. 471-478. USAF-sponsored consideration of an extension of Schwarz's classical reflection principle to functions which are harmonic of higher order.

OPERATIONAL FORMULAE FOR RESPONSE CALCULATIONS. Appendix - EXAMPLES OF SOLUTIONS OF DIFFERENTIAL EQUATIONS AND RESPONSE PROBLEMS BY USING THE FORMULAE OF TABLES I-V. S. Neumark. Gt. Brit., RAE Rep. Aero. 2570, June, 1956. 65 pp. Systematic tables of formulas to facilitate the solution of response problems reducible to linear differential equations with constant coefficients and simple forcing functions. The formulas provide a rapid and direct index to operational equivalents of a wide class of simple functions, and functional equivalents of a large number of operational expressions. Only functions whose operational equivalents are algebraic fractions are included, with special comprehensive treatment given to operational fractions of the first through fourth order and additional tabulations for the reduction of fifth and sixth order fractions to combinations of lower order fractions.

MAXIMUM LIKELIHOOD ESTIMATION OF RESTRICTED PARAMETERS. H. D. Brunk. Mo. U. Dept. Math. TR 7 (AFOSR TN 56-391), Sept., 1956. 26 pp. 15 refs. Discussion of relevant techniques applicable to independent random sampling from a finite number of populations belonging to exponential families, when the parameter point is known to lie in a proper subset of its "natural" range. "Exponential family" is defined and the problem is expressed as a minimum one with side conditions. Includes study of a geometric approach to the question of computing the maximum likelihood estimator (MLE) when it may be viewed as a problem in nonlinear programming; description of a method for obtaining a solution when the parameter point is re-

stricted to a convex subset of its "natural" range; and discussion of a property of the MLE related to sufficiency.

MECHANICS

IMPACT PHENOMENA AT HIGH SPEEDS. M. E. Van Valkenburg and W. G. Clay. J. Appl. Phys., Oct., 1956, pp. 1,123-1,129. 13 refs. OSR-supported experimental investigation using 1/8-in. diameter spherical pellets of aluminum, magnesium, steel, brass, lead, and zinc to study metal-to-metal impact in the velocity range of 1 to 5 mm./μsec. Tests relating to the mechanisms of cratering and the perforation of thin targets are presented. Results indicate that the volume of the crater per unit energy of the impacting pellet is essentially constant for each material and that the penetration is proportional to the pellet velocity so long as this velocity is less than that of sound in the target material. Includes description of an attempt to model very high speed impact by using soft wax targets in which the sonic velocity is less than the impacting velocity.

METEOROLOGY

RESONANCE SCATTERING BY ATMOSPHERIC SODIUM. I---THEORY OF THE INTENSITY PLATEAU IN THE TWILIGHT AIRGLOW. J. W. Chamberlain. J. Atmos. & Terrestrial Phys., Aug.-Sept., 1956, pp. 73-89. 21 refs. ARDC-sponsored application of Chandrasekhar's theory of radiative transfer to the twilight airglow in order to determine the number of Na atoms per cm.^{2} (column) from a comparison of theoretical results to those obtained from measurements of absolute brightness, the variation of brightness during twilight, and the intensity ratio D_2/D_1. Numerical results are presented for a layer-scattering solar D-line radiation and observed in the zenith or at zenith distance 75^o, and the effect of diffuse radiation of the D-lines by the ground is approximately evaluated. Includes discussion of methods to reconcile the discrepancy between Hunten's observations of absolute brightness during winter and the theoretical values. Results of comparisons suggest that the abundance of Na varies between 10^9 (summer) and nearly 10^{10} (winter) atoms/cm.^{2} (column), and that the D_2/D_1 ratio may be the most reliable means of determining wintertime values of this abundance.

RESONANCE SCATTERING BY ATMOSPHERIC SODIUM. II - NIGHTGLOW THEORY. J. W. Chamberlain and B. J. Negaard. III - SUPPLEMENTARY CONSIDERATIONS. D. M. Hunten. J. Atmos. & Terrestrial Phys., Oct., 1956, pp. 169-183. 27 refs. ARDC-supported application of the radiative transfer theory to the layer emitting the Na D lines in the nightglow. Three models are considered: primary excitation concentrated at the bottom of the Na layer, evenly distributed through the layer, and concentrated at the top. Includes discussion of the van Rhijn heights and of the ratio D_2/D_1 to be expected for the various assumed models and for true height of approximately 85 km.

DRAG COEFFICIENTS FOR DROPLETS AND SOLID SPHERES IN CLOUDS ACCELERATING IN AIRSTREAMS. Appendix - APPLICATION OF DRAG-COEFFICIENT EQUATIONS TO SPRAY EVAPORATION. R. D. Ingebo. US, NACA TN 3762, Sept., 1956. 31 pp. Experimental investigation over a range of airstream pressures, temperatures, and velocity conditions, based on diameter and velocity data for the individual droplets and spheres obtained with the aid of a special high-speed camera. An equation relating distance and time, which permits calculation of the trajectories of solid spheres and the relation of droplet diameter to distance when evaporation rates are low, is derived from an expression for drag coefficient. A graphical method is used to determine the droplet diameter to distance ratio when evaporation rates are high.

MISSILES

THEORETICAL AND EXPERIMENTAL NORMAL FORCE DISTRIBUTION ON A CONE-FRUSTUM BODY AT SUPERSONIC SPEEDS. W. D. Murphree. USRA OML Rep. 2R19F, Sept. 15, 1956. 83 pp. 10 refs. Consideration of methods for calculating the aerodynamic characteristics of a cone-frustum body, and presentation of the results of theoretical and experimental normal-force distribution investigations. Includes discussion of analytical and test data on initial normal force, pitching moment slope, and center of pressure. Results of study indicate that second-order shock-expansion theory is applicable to typical cone-frustum bodies for a range of Mach Numbers and gives the most accurate predictions of all the theories investigated.

NAVIGATION

Electronic Aids

THEORETICAL CONCEPTS OF NEW AIRBORNE NAVIGATION SYSTEMS. D. J. Green. SAE Natl. Aero. Meeting, Los Angeles, Oct. 2--6, 1956, Preprint 836. 11 pp. Description of a new, hybrid navigational system combining the advantages of both the self-contained and externally referenced systems, with discussion of the Self-Correcting Automatic Navigator (SCAN) and its governing concept of statistical data filtering. The limitations of each of the conventional systems are outlined. In the SCAN system, data from both self-contained dead-reckoning instrumentation and a ground-reference position-indicating system of the radio type are compared and any discrepancy between these sets of data is applied to an "optimum" filter, the output of which supplies correction data in order to bring the dead-reckoning computer into long-term agreement with such samples of data as are supplied by the external system.

PHOTOGRAPHY

STAR CALIBRATION PROCEDURES FOR CZR-1 CAMERAS. E. Stern and A. E. Hoffmann-Heyden. USAF MTC TN 56-62, Aug., 1956. 23 pp. Description of a test designed to record star trails from different parts of the sky with the CZR-1 camera in

order to evaluate the feasibility of CZR-1 dial orientation and to obtain unbiased statements of the dial-data reliability. Recordings are obtained with the aid of an especially designed venetian-blind type shutter with a driver sequencer for its control. Results show that the method used is feasible for star photography with simultaneous introduction of time identification.

PHYSICS

MOTION OF A SPHERE THROUGH A CONDUCTING FLUID IN THE PRESENCE OF A STRONG MAGNETIC FIELD. K. Stewartson. Proc. Cambridge Philos. Soc., Apr., 1956, pp. 301-316. 14 refs. Theoretical investigation of a perfectly conducting sphere showing that if the fluid velocity is ultimately steady then it is two-dimensional, and that a cylinder of fluid, whose generators are parallel to the direction of the field, moves with the sphere as if solid. The streamlines outside the cylinder are considered as straight lines if the sphere moves in the direction of the field, but have to execute sharp turns if it moves at right angles to the field.

A PLANE CONTINUUM NO TWO OF WHOSE NON-DEGENERATE SUBCONTINUA ARE HOMEOMORPHIC. R. D. Anderson and Gustave Choquet. Inst. Advanced Study, Princeton, N. Y. (AFOSR TN 56-315 [AD 94-851], July, 1956. 9 pp. Detailed constructive proof of the existence of a continuum M which does not separate the plane. Modifications of this construction are suggested in order to yield (a) a continuum M' every nondegenerate subcontinuum of which does separate the plane and (b) a one-dimensional metric continuum M^0, no nondegenerate subcontinuum of which is imbeddable in the plane and no two of whose nondegenerate subcontinua are homeomorphic to each other.

POWER PLANTS

Jet & Turbine

RELIABILITY OF COMBUSTION EFFICIENCY EVALUATION FOR JET PROPULSION BASED UPON AERODYNAMIC MEASUREMENT OF COMBUSTION TEMPERATURE. G. S. Bahn. Jet Propulsion, Oct., 1956, Pt. I, pp. 861-866, 887. 38 refs. Theoretical investigation of the sources and magnitudes of both systematic and random errors. Results indicate that, when care is taken to avoid certain potential systematic errors by corrections which do not, themselves, introduce random errors, and with the use of reasonably refined instrumentation, the major source of random error is the evaluation of nozzle-exit Mach Number. The probable magnitude of the resulting error in combustion efficiency, expressed as either a temperature-rise ratio or a ratio of fuel/air ratios to compare theoretical and actual performance, is about ± 5%.

THE PROBLEMS OF THE TURBOJET ENGINE AS A PROPULSION ENGINE FOR SUPERSONIC FLIGHT. M. J. Zucrow. (IAS Section Meeting, Indianapolis, Mar. 12, 1956.) Aero. Eng. Rev., Dec., 1956, pp. 44-51, 61. 12 refs. Discussion of turbo-jet engines in terms of three performance parameters: specific engine weight, thrust per unit of frontal area, and thrust specific fuel consumption. Engine weight is considered, taking into account the various factors that affect compressor and turbine weight. The effect of flight speed on design point performance is analyzed considering the diffuser performance, the effects of Mach Number on the compressor outlet, and the effect of flight speed on specific thrust. Compressor performance, combustion problems, and the need for converging-diverging exhaust nozzles are discussed. Five research problems that must be solved in order to produce an engine for the higher Mach Number regime are outlined.

TESTS ON A SINGLE-STAGE TURBINE COMPARING THE PERFORMANCE OF TWISTED WITH UNTWISTED ROTOR BLADES. I. H. Johnston and L. R. Knight. Gt. Brit., ARC R&M 2927, 1956. 11 pp. BIS, New York, $0.63. Performance results show that, for the incidence range covered by the tests, an untwisted constant-section blade of approximately 10% reaction possesses characteristics of pressure loss and deflection nearly identical to those of a conventional rotor blade twisted along its length to conform to the requirements of radial equilibrium, the mean diameter sections of the two blades being identical. The rotor blade section used provides a gas outlet angle and degree of reaction which, although lower than those employed in current aircraft engine practice, may well become typical for designs requiring a higher volumetric flow per unit turbine frontal area.

FURTHER INVESTIGATION OF THE FEASIBILITY OF THE FREEZE-CASTING METHOD FOR FORMING FULL-SIZE INFILTRATED TITANIUM CARBIDE TURBINE BLADES. E. M. Grala. US, NACA TN 3769, Oct., 1956. 19 pp. Tests to determine if the problems encountered during the process can be overcome. These problems include: segregations and large holes in the casting, particularly in the root area; excessively low casting densities in the as-cast state; and gradations in density along the lengths of the blades. In carrying out the procedure, a thick slip of titanium carbide is prepared with a small amount of binder, cast into a mold by vibration, centrifuged, and frozen to retain the shape of the mold. Then the casting is dried in an absorbent sand sintered by conventional means to permit infiltration of the porous casting by a nickel- or cobalt-base alloy. In the investigation, densities and radiographs of the blade prior to infiltration are used as criteria for soundness.

Ram-Jet & Pulse-Jet

VARIAZIONE DELLE GRANDEZZE CARATTERISTICHE DELL'AUTOREATTORE CON O SENZA REGOLAZIONE DELLE AREE DI EFFLUSSO. Lodovico Pascucci. L'Aerotecnica (Rome), Aug., 1956, pp. 270-275. In Italian. Extension of Casci results for the behavior of a ram-jet in supersonic flight showing the difference between the case of a complete jet expansion in every operating condition and that of a fixed dimension diffuser, where super- and subexpansion fields are present. The thrust and efficiency losses in the superexpansion field

are given, and the use of a simple convergent diffuser at Mach Numbers less than four to avoid these losses is shown.

Reciprocating

SUL CALCOLO DELLE VIBRAZIONI FLESSO-TORSIONALI DEL SISTEMA ALBERO-ELICA. G. S. Lavina. L'Aerotecnica (Rome), Aug., 1956, pp. 278-290. In Italian. Analysis of the vibration modes of a crankshaft-airscrew system split into two separate systems. The analysis of the complete system without using the splitting is also discussed. A numerical example of bending of an airscrew with 12^{o} of freedom is given and it is compared with results obtained by the Morris escalator method.

Rocket

THE THEORETICAL SPECIFIC THRUST OF A ROCKET MOTOR FOR THE C-H-N-O-F SYSTEM. M. S. Morgan, J. Silverman, and W. T. Webber. Jet Propulsion, Oct., 1956, Pt. I, pp. 874-877, 891. USAF-sponsored derivation of curves of theoretical Isp for various hypothetical compositions and heats of formation at a chamber pressure of 500 psia and a nozzle exit pressure of one atmosphere. The curves are based on the assumption of isentropic expansion of combustion products whose chemical composition is frozen at chamber conditions versus oxidation ratio. It is shown that, within the range of values of the variables chosen, the I_{sp} for any propellant combination and mixture ratio can be determined from the graphs by interpolation or, for greater accuracy, by suitable cross-plots, some examples of which are included.

THE EFFECT OF VEHICLE STRUCTURE ON PROPULSION SYSTEM DYNAMICS AND STABILITY. R. S. Wick. Jet Propulsion, Oct., 1956, Pt. I, pp. 878-887. 13 refs. Theoretical investigation of the general case, with the analytical methods developed herein and servomechanism techniques applied to a monopropellant rocket-propelled vehicle. The complete system, which is equivalent to a multiloop servomechanism, is represented by a block diagram, and appropriate transfer functions are estimated for various portions of the system. Over-all stability is evaluated by means of the Satche diagram which is analogous to a Nyquist diagram, and results are presented in terms of natural frequency of the vehicle structure, combustion lag, and mass distribution between various portions of the vehicle.

L'UTILIZZAZIONE DELLA POTENZA NELLA PROPULSIONE A RAZZO. Pietro Formentini. L'Aerotecnica (Rome), Aug., 1956, pp. 255-264. 16 refs. In Italian. Calculations of the power utilized in rocket propulsion, starting from the definition of various amounts of power and their respective efficiencies. Includes derivation of a relation suitable for calculating the instantaneous propulsive efficiency in the general case of a rocket in variable motion and presentation at the same time of a graphic illustration of the pattern of propulsive efficiencies. The power utilized by the V-2 is determined, and checked through the evaluation of the vehicle's potential and kinetic energy. Also includes a discussion on the peculiarity of the speed/specific-consumption ratio, and a table of the cost of speed for the various systems of propulsion of air vehicles.

PROPELLERS

AN AERODYNAMIC THEORY OF A SUPERSONIC PROPELLER. D. E. Ordway. Cornell U. Grad. Sch. Aero. Eng. OSR TN 56-287, June, 1956. 170 pp. 27 refs. Evaluation of a supersonic propeller with blades attached to an infinite cylinder as a hub, considering the forward speed as subsonic but the relative speed at each section as supersonic. The lightly loaded blades are represented by a surface distribution of appropriately modified sources in a manner similar to ordinary supersonic thin-wing theory. These sources are found by approximating the exact potential for a constant-strength compressible source traveling along a helical path. A sample calculation for a twisted flat plate blade shows that the pressure distribution is the Ackeret value at the leading edge and remains essentially at this value over the first half of the section. However, as the trailing edge is approached, it rises about 20% above the Ackeret value because the opening up of the forward Mach cone increases the number of contributing sources. It is suggested that problems of blade interference and wake-induced effects could probably be handled by proper manipulation of the doublet potential.

ROTATING WING AIRCRAFT

A THEORETICAL ESTIMATE OF THE EFFECTS OF COMPRESSIBILITY ON THE PERFORMANCE OF A HELICOPTER ROTOR IN VARIOUS FLIGHT CONDITIONS. Alfred Gessow and A. D. Crim. US, NACA TN 3798, Oct., 1956. 33 pp. Analysis using numerical methods of the effects of compressibility arising from high-tip-speed operation on flapping, thrust, and power of a helicopter rotor over a wide range of forward flight conditions. The sample rotor is assumed to have untapered blades with constant-thickness airfoil sections that are represented by specific set of two-dimensional lift and drag characteristics that vary with Mach Number. Results for the particular set of airfoil characteristics used indicate minor increases in rotor flapping and thrust arising from increasing rotor tip speed from 350 to 750 ft. per sec. The largest effect noted is an increase in profile-drag power on the advancing side of the disk that is proportional to the amount by which the blade-tip Mach Number exceeds the drag-divergence Mach Number. These effects of compressibility appear to be independent of blade twist, but are a function of the airfoil characteristics employed in the analysis.

AN EXPRESSION FOR ROTOR BLADE SECTION LOADING INCLUDING REVERSED FLOW EFFECTS. F. E. Bradley. AHS J., Oct., 1956, pp. 32, 33. Derivation of an equation which is "closed" with respect to azimuth and is one step more generalized than those of Leone and Wheatley. Applicable to loads analysis, particularly where normal mode expansion methods are used and where it is necessary to perform numerical integrations of the product of the blade loading and the blade natural mode shapes.

SPACE TRAVEL

PERTURBATIONS OF A SATELLITE'S ORBIT DUE TO THE EARTH'S OBLATENESS. Leon Blitzer, Morris Weisfeld, and A. D. Wheelon. J. Appl. Phys., Oct., 1956, pp. 1,141-1,149. Theoretical investigation, neglecting atmospheric deceleration, of the free-flight motion of a satellite around a spherical earth, and extension of the analysis to take into account the earth's oblateness, represented by an additional quadrupole field. Results indicate that perturbations of the usual planar motion for nearly circular orbits may be described analytically and are characterized by a precession of the orbit plane around the equator (i.e., a regression of nodes) amounting to as much as 40 miles per revolution; the large magnitudes of these effects suggest that the satellite's motion, as measured by conventional radio techniques, should make it possible to determine the earth's oblateness to a new precision.

STRUCTURES

ELASTIC-PLASTIC TORSION OF CIRCULAR RING SECTORS. W. Freiberger. Quart. Appl. Math., Oct., 1956, pp. 259-265. Solution to the problem of uniform torsion of ring sectors with circular cross section under the assumption of perfect plasticity. The elastic-plastic case is solved by a semi-inverse method. When the entire ring is plastic a discontinuity of stress appears which may be regarded as the limiting case of an elastic core. The solution for this discontinuous fully plastic stress distribution is exact. The difference between the two solutions is negligible for ratios of ring radius to cross-section radius occurring in practical applications to helical springs of small pitch.

O KONTAKTNYKH NAPRIAZHENIIAKH NA KONTURE STENKI. V. V. Sokolovskii. Prikl. Mat. i Mekh., Sept.-Oct., 1956, pp. 588-598. In Russian. Investigation of the plane boundary equilibrium of connecting media, bounded by a curvilinear wall, which is accompanied by a certain fracture curve. The contact tensions are determined quantitatively, given in some cases in the simple closed form.

Beams & Columns

O KRUCHENII KRUGLOGO BRUSA S TRESHCHINOI PO DUGE OKRUZHNOSTI ILI PO RADIUSU. E. A. Shiriaev. Prikl. Mat. i Mekh., June-Aug., 1956, pp. 555-558. In Russian. Investigation of the problem of twisting of uniform circular beams having a slit along the circumferential curve or along the radius. The solution is based on the conformal reaction, and Muskhelishvili's formulas are used for defining complex functions of twisting and for calculating the stiffness during the twisting process.

Cylinders & Shells

A POWER SERIES SOLUTION OF THE NON-LINEAR EQUATIONS FOR AXI-SYMMETRICAL BENDING OF SHALLOW SPHERICAL SHELLS. R. M. Simons. J. Math. & Phys., July, 1956, pp. 164-176. Analysis considering a simply-supported and a clamped edge in order to determine the stresses and deformations of thin, shallow segments of spherical shells subjected to uniform normal pressure. A solution is obtained for the problem of small finite deflections and a systematic procedure is developed for determining the required leading coefficients for the power series solution to satisfy the boundary conditions. The technique given for a shallow shell contains as a special case the corresponding results for a flat plate.

O NEKOTORYKH PRIAMYKH METODAKH V NELINEINOI TEORII POLOGIKH OBOLOCHEK. I. I. Vorovich. Prikl. Mat. i Mekh., June-Aug., 1956, pp. 449-474. 20 refs. In Russian. Nonlinear differential equations for slanted shells are studied theoretically and the application of some direct methods to this problem is analyzed.

Elasticity & Plasticity

ON THE SOLUTION OF PROBLEMS OF DYNAMIC PLANE ELASTICITY. J. R. M. Radok. Quart. Appl. Math., Oct., 1956, pp. 289-298. Application of complex variable methods to the dynamic equations of the plane theory of elasticity. A stress function is introduced and it is shown to be a solution of a fourth order partial differential equation, which reduces to a generalized biharmonic equation of the type occurring in anisotropic elasticity. This stress function can be expressed in terms of analytic functions of two complex variables, and the stress and displacement components may be found in terms of these functions. Three problems are solved by this method: the moving Griffith crack, the parabolic punch moving over a half-plane, and a moving dislocation.

Plates

TRANSVERSE BENDING OF A THIN CIRCULAR PLATE LOADED NORMALLY OVER AN ECCENTRIC CIRCLE. W. A. Bassali. Proc. Cambridge Philos. Soc., Oct., 1956, pp. 742-749. 15 refs. Analysis showing the power of the complex variable method by finding the appropriate complex potentials corresponding to the load over an eccentric circular patch. This investigation completes the solution of the problem of a circular plate with an eccentric circular patch symmetrically loaded with respect to the common diameter of the plate and patch. The solution is obtained in finite terms for a clamped boundary.

THE COMPRESSIVE BUCKLING OF A CLAMPED PARALLELOGRAM PLATE WITH A LONGITUDINAL STIFFENER ALONG THE CENTRE-LINE. J. Guest. Australian J. Appl. Sci., Sept., 1956, pp. 191-198. Theoretical investigation using Galerkin's method to obtain the compressive buckling in the line of the applied stress and a slight modification of Iguchi's functions for the deflection of the plate. Results, shown graphically and compared with Wittrick's results for the unstiffened case under the same constraints, indicate that for the particular elastic parameters chosen, the least buckling load of the plate is associated with a symmetric buckling mode.

BENDING OF AN ELASTICALLY RESTRAINED CIRCULAR PLATE UNDER A LINEARLY VARYING LOAD OVER AN ECCENTRIC CIRCLE. W. A. Bassali. Proc. Cambridge Philos. Soc., Oct., 1956, pp. 734-741. 10 refs. Analysis to determine the complex potentials and deflection at any point of a thin, circular plate with a normal, linearly varying load over an eccentric circle under a general boundary condition including the usual clamped and hinged boundaries.

Sandwich Structures

LES NIDS D'ABEILLE EN ALLIAGE LÉGER ET LEUR APPLICATION À LA CONSTRUCTION SANDWICH. G. Bruner and G. Montantême. Docaéro, Mar., 1956, pp. 39-56. In French. Discussion of methods of fabrication, control, physical properties such as density and strength, preparation for glueing, and construction of components from the honeycomb material. Methods of varying the local density of structures by the use of inserts and the forming of edges on sandwich assemblies are also described. Typical structures include an air-brake (flap) and a leading edge for the Vautour jet attack aircraft.

THERMODYNAMICS

AN EXPERIMENTAL INVESTIGATION ON THE INTERACTION EFFECTS IN THE COMBUSTION OF DROPLETS. Gregorio Millán and C. S. Tarifa. Inst. Nac. Tec. Aero. Esteban Terradas AFOSR TR 56-38 [AD 95208], May, 1956. 44 pp. 22 refs. Benzene fuel tests including measurements on the combustion of isolated drops for determining the scattering of results in order to isolate the interaction effects. Includes three series of experiments on (1) combustion of two drops side by side, (2) combustion of a drop within the wake of another, and (3) evaporation of a drop within a diffusion flame formed on the free surface of a fuel. Investigation uses the Godsave's method of measuring on photographic films the time variations of the mean diameter of drops suspended from a quartz filament.

CALCULATION OF REACTION RATE PARAMETERS FROM FLAME SPEED DATA ON LAMINAR FLAMES. I. E. Mayer and H. Carus. ARDE Assoc., TN 4555-2 (AFOSR TN 56-286), July, 1956. 22 pp. 20 refs. Calculation of the laminar flame speeds by numerical methods based on Arrhenius's law. The procedure is applied to the determination of the dimensionless parameters, E and B', for propane-air mixtures treated as a second order reaction. Two points of an experimentally observed flame-speed to mixture ratio curve are matched to corresponding calculated flame-speeds, and plausible agreement is obtained with calculated results based on Semenov's approximate flame-speed formula. Further study shows that agreement between experimental and calculated flame-speeds, based on the Arrhenius law, cannot be obtained for an extended range of mixture ratios if the overall second-order reaction is first order with respect to each reactant species.

A PRELIMINARY STUDY ON SHOCK IGNITION. Ryuma Kawamura and Saburo Yui. J. Japan Soc. Aero. Eng., Sept., 1956, pp. 7-14. Investigation of shock ignition on various fuel-air and fuel-oxygen mixtures in order to determine their critical ignition pressures. To amplify the strength of the incoming shock, conical end-tubes of various angles and a shock concentration device originated by Kantrowitz are used. The shock concentration device is more effective. The effect of mixture ratio on the critical ignition pressure is also investigated and it is found that, except for the hydrogen-oxygen mixtures, the minimum critical ignition pressure is near the stoichiometric mixture ratio.

RECHERCHES SUR LA COMBUSTION D'UN MÉLANGE D'HYDROCARBURES. Jean Rappeneau. France, Min. de l'Air PST 318, 1956. 90 pp. 74 refs. SDIT, 2 Av. Porte-d'Issy, Paris 15, Frs. 1,100. In French. Study of the combustion of kerosene in air. Includes theoretical determination of temperatures reached and of concentrations of products formed by complete combustion without dissociation. Classical methods of calculation are used for determining temperatures and concentrations of mixture constituents. Also includes development of an analytical method for determining the state of combustion by analyzing combustion gases and by measuring temperatures and quantities of air and fuel used in the combustion process. Gas analyses and temperature measurements are performed as a function of the air/fuel ratio, and test apparatus used for studying kerosene combustion in turbojets is described.

SOME EFFECTS OF SMALL-SCALE FLOW DISTURBANCE ON NOZZLE-BURNER FLAMES. E. L. Wong. US, NACA TN 3765, Sept., 1956. 19 pp. 14 refs. Experimental investigation using small-diameter-wire grids as turbulence generators in a 1/2-in. nozzle burner to produce laminar-like propane air flames subject to flow disturbances that are small in scale compared to the reaction-zone thickness. A hot-wire anemometer method is also used to measure the flow disturbance intensity in the cold flow with and without grids in place. Both laminar-like and brush-like flames are obtained, and the results indicate, in agreement with Damkohler's theory on the effects of small-scale turbulence, that some of the laminar-like flames obtained for grid-disturbed flow have a slightly higher burning velocity than "true" laminar flames, i.e., those obtained without the use of a grid. Further results reveal that the brush-like flames are similar to those obtained with pipe turbulent flow, indicating that their burning-velocity dependence on a "flow-disturbance" Reynolds Number compares favorably with that obtained for pipe turbulent flames.

ANALYSIS OF LAMINAR FLAME PROPAGATION LIMITS DUE TO THERMAL LOSS. E. Mayer. ARDE Assoc. TN 4555-3 (AFOSR TN 56-478) [AD 97362], Sept., 1956. 22 pp. 10 refs. Investigation based on simplified (Semenov) relations in thermal flame theory. Results indicate that flame propagation limits, governed by the heat loss, occur at fi-

nite combustible mixture strengths and finite low pressures, when heat loss from the flame front to the cold wall of a cylindrical burner is assumed to be proportional to flame thickness.

MECHANISM OF GENERATION OF PRESSURE WAVES AT FLAME FRONTS. Boa-Teh Chu. US, NACA TN 3683, Oct., 1956. 20 pp. Theoretical investigation with comparison of the performance of a flame with that of a heater, and examination of the conditions under which the two are dynamically equivalent. Results indicate that the principal physical cause of the production of pressure waves at the flame front is the change in the rate of heat release by the flame, and that this change can be induced by a change in the flame area (accompanied by any change in flame configuration) and/or a change in flame speed and/or a change in the density of the unburned medium. It is proved that the pressure waves generated at plane flame fronts of zero thickness are all due to the change in the rate of heat release at the flame front when the specific heat ratios of the burned and unburned gases are the same.

A THEORETICAL ANALYSIS OF HEAT TRANSFER IN REGIONS OF SEPARATED FLOW. D. R. Chapman. US, NACA TN 3792, Oct., 1956. 47 pp. 12 refs. Investigation of the flow field consisting of a thin, constant pressure, viscous mixing layer separated from a solid surface by an enclosed region of low-velocity (dead) air, for the case of zero boundary-layer thickness at the position of separation, using the law of conservation of energy to relate calculated conditions with the separated mixing layer to the rate of heat transfer at the solid. The physical model is applied to laminar separations in compressible flow for various Prandtl Numbers and to turbulent separations for a Prandtl Number of unity in low-speed flow without injection. Results of the solution of the viscous flow differential equations (with regard to laminar separations) for the enthalpy and velocity profiles within the thin layer where mixing in dead air takes place, are presented in tabular form for Prandtl Numbers between 0.1 and 10.

INTERMOLECULAR FORCES AND EQUATION OF STATE OF GASES. Taro Kihara. U. Wis. NRL Dept. Chem. TR WIS-AF-3, Sept. 26, 1956. 45 pp. 18 refs. Investigation using quantum mechanics of the van der Waals interaction between three distant atoms. A standard model of the intermolecular potential is constructed and applied to the equations of state for gases. Dense gases at high temperatures are discussed, and applications are made to detonation in condensed explosions.

TABLES OF THERMODYNAMIC PROPERTIES OF AIR FROM 3000°K TO 10,000°K. C. E. Treanor and J. G. Logan, Jr. Cornell Aero. Lab. Rep. AD-1052-A-2 (AFOSR TN 56-343), June, 1956. 29 pp. 11 refs. Tables of partition functions for the various components of high-temperature air, temperature derivatives of partition functions, equilibrium constants for the reactions that are assumed to occur, mole fraction concentrations for the constituents, and pressure, entropy, and enthalpy of the air - each quantity tabulated at 1000° intervals for densities ranging from 10^{-6} to 10^{+1} atmospheres.

THE CALCULATION OF THE THERMODYNAMIC PROPERTIES OF AIR AT HIGH TEMPERATURES. Appendix I, II - PARTITION FUNCTIONS FOR ATOMS AND DIATOMIC MOLECULES. Appendix III - APPROXIMATE PROCEDURES FOR CALCULATING PARTITION FUNCTIONS. J. G. Logan, Jr. Cornell Aero. Lab. Rep. AD-1052-A-1 (AFOSR TN 56-344), May, 1956. 68 pp. 17 refs. Methods for determining the equilibrium concentration and values for energy, enthalpy, entropy, pressure, specific heat, molecular weight, and the speed of sound in the temperature range of 1,000°K. to 20,000°K. Includes complete tables of constants derived from spectroscopic data for the various components and corrected by using the latest available data. Approximate values are suggested where exact ones have not been calculated. The calculations for nitrogen are based on the dissociation energy value 9.756 ev., and all calculations are based on the composition of dry air at NACA standard sea level conditions, on the assumption of chemical equilibrium at all temperatures and densities, and on the hypothesis that the perfect gas law is valid.

BILANS POTENCJONALNY PROCESÓW FIZYCZNYCH WYNIKAJĄCYCH Z DRUGIEJ ZASADY TERMODYNAMIKI. Jan Szargut. Arch. Budowy Maszyn (Warsaw), No. 3, 1956, pp. 231-276. 23 refs. In Polish, with summaries in English and Russian. Analysis of the potential balance of physical processes, based on the second law of thermodynamics, to derive equations for the general case and for the energetic potentials of (a) a jet of the working fluid intersecting an immovable diathermic envelope, (b) of the working fluid in the container, and (c) of a jet intersecting a movable diathermic envelope. The principles involved in calculating the potential of an energetic system are formulated along with the increment of the energetic potential of the heat source. Includes description of a method for representing the potential balance on Sankey's diagram and examples of the potential balancing of various physical processes.

VTOL & STOL

FLIGHT INVESTIGATION OF THE STABILITY AND CONTROL CHARACTERISTICS OF A VERTICALLY RISING AIRPLANE RESEARCH MODEL WITH SWEPT OR UNSWEPT WINGS AND x- OR +-TAILS. R. H. Kirby. US, NACA TN 3812, Oct., 1956. 30 pp. Results of an investigation in the Langley Free-Flight Tunnel consisting of hovering flight in still air at a considerable height above the ground, hovering flights very close to the ground, vertical take-offs and landings, flights through the transition range from hovering to normal forward flight, and sideways translational flights.

PERFORMANCE DIAGRAMS FOR FREE AND DUCTED PROPELLERS. H. B. Helmbold. Fairchild Aircr. Div., Eng. Rep. R221-013, Mar., 1956.

34 pp. 15 refs. Derivation of performance curves for the thrust coefficient of fixed, variable-pitch, and shrouded propellers. A viscous flow diagram is derived from experiments and a potential-flow formula is used to convert the basic diagram into individual diagrams according to individual values of blade number and solidity. For variable pitch propellers curves are presented for a reduced coefficient (κ_{λ}) and the ideal advance ratio (λ_i). For the fixed pitch propellers curves are presented as functions of the ratio of pitch to diameter (H/D), solidity (σ), and the ideal advance ratio. Curves for the ducted propeller are prepared from the curves of a free propeller, using a ratio derived from the differences in the ideal thrust coefficients between free and shrouded propellers.

COMPRESSIBILITY EFFECT ON A SHROUDED PROPELLER. H. B. Helmbold. Fairchild Aircr. Div., Eng. Rep. R221-012, Nov., 1955. 16 pp. Theoretical analysis of compressibility effects on the slipstream shape, on the propeller discontinuity, and on the static total thrust. A numerical example is given to illustrate the slipstream shape problem, and the results indicate that the widening effect of the shroud on the slipstream is diminished by compressibility. A series of equations are derived, the solution of which, in the form of the Hugoniot shock-wave equation, indicates that the entropy increases discontinuously along the propeller plane. From this deduction another expression for the specific energy increase is obtained in order to establish the relation between propeller discontinuity and slipstream velocity, applying the energy theorem to the states of flow at infinity inside and outside the slipstream, and the results provide a method for computing the ratio of the densities at infinity in these regions. Results of the static thrust analysis show that appreciable losses occur only when the slipstream Mach Number approaches its upper limit determined by the sonic condition in the throat.

TEORIIA NESUSHCHEGO VINTA PRI NULEVOM UGLE ATAKI. A. P. Proskuriakov. Prikl. Mat. i Mekh., July-Aug., 1956, pp. 519-531. In Russian. Development of a theory of an airscrew at zero angle of attack. Includes discussion of flow past the airscrew with the formulas for the induced velocity derived for the whole of the space. The vortex sheet behind the airscrew is also analyzed and the circulation along the blade is neglected.

EXPLORATORY INVESTIGATION OF THE EFFECTIVENESS OF BIPLANE WINGS WITH LARGE-CHORD DOUBLE SLOTTED FLAPS IN REDIRECTING A PROPELLER SLIPSTREAM DOWNWARD FOR VERTICAL TAKE-OFF. R. H. Kirby. US, NACA TN 3800, Oct., 1956. 22 pp. Evaluation of the effects of chord length, flap deflection, propeller position, end plates, fuselage, and ground proximity on the efficiency of the wing system in turning the propeller slipstream. Results show that it is possible to turn the propeller slipstream 90° so that the resultant force vector of the wing-propeller combination is normal to the propeller shaft and is 80% of the magnitude of the propeller thrust. When the model is near the ground, the slipstream is turned only about 75° but the resultant force is increased to about 88% of the thrust.

WIND TUNNELS & RESEARCH FACILITIES

THE TIP CORRECTION FOR WIND-TUNNEL TESTS OF PROPELLERS. T. R. Goodman. J. Aero. Sci., Dec., 1956, pp. 1,094-1,098. Low-speed, incompressible, quantitative analysis assuming a lightly loaded propeller consisting of a large number of blades in order to derive a wall-tip correction for the case of a full-scale propeller tested in a wind tunnel whose cross section is about the same size as the propeller disc. Graphs are given for the computation of corrections in thrust and efficiency for two-, three-, and four-bladed propellers as a function of advance ratio and ratio of propeller radius to tunnel radius. It is shown that the effect of the walls is to increase the thrust and decrease the propulsive efficiency.

STRUT INTERFERENCE ON AN AEROFOIL. J. L. Taylor. Aircraft Eng., Oct., 1956, p. 362. Method for the direct calculation of interference effects of struts in a wind tunnel. The theory is given for a rectangular airfoil supported by struts enclosed in streamlined tubular shields which are assumed to be of constant section. Interference on the airfoil consists of induced camber due to flow curvature associated with downwash, and "blockage" originated by local change in tunnel velocity due to strut disturbance.

GEOMETRICAL OPTICS OF ANGULAR STRATIFIED MEDIA. R. Sedney. Quart. Appl. Math., Oct., 1956, pp. 225-230. Analysis of angular stratified media in which the index of refraction is a function of the polar angle with respect to some line. The two and three-dimensional cases are considered, but it is shown that in both cases the integration could not be reduced to a quadrature. However, in the two-dimensional case, the problem can be reduced to a quadrature plus a first order differential equation. A similarity property of the light paths leads to some general conclusions about the behavior of light rays traversing a cone. An application to the interferometric method of observing supersonic flows shows that a conical flow test is valid including the refraction effect.

EXPERIMENTAL HYPERBALLISTICS. H. H. Kurzweg and R. E. Wilson. (IAS Natl. Summer Meeting, Los Angeles, June 18-21, 1956.) Aero. Eng. Rev., Dec., 1956, pp. 32-38. Discussion of the problems in model testing at hypersonic speeds summarizing the highlights of various experimental approaches which have contributed to the understanding of hypersonic phenomena. Two different methods are being used; the models are either subjected to the impact of air streams in wind tunnels, shock tubes, etc., or they are accelerated by a gun or rocket through air or any other gas at rest under usually well-defined conditions. Both methods have also been combined by firing models from a gun in wind tunnels. Emphasis is placed on free-flight work in ranges, and developmental requirements to meet future needs are given.

is found in the physical plate by a standard form of the method of characteristics.

Pressure and Boundary-Layer Measurements on a Two-Dimensional Wing at Low Speed. G. G. Brebner and J. A. Bagley. *Gt. Brit., ARC R&M 2886* (Feb., 1952), 1956. 47 pp. 10 refs. BIS, New York, $2.25. Experimental investigation with results integrated to give lift, drag, and aerodynamic-center characteristics in order to check (a) some calculation methods for the growth of the turbulent boundary layer and (b) a particular calculation method for the effect of a known boundary layer on the pressure distribution.

Experimentelle Untersuchungen an schiebenden und gepfeilten Flügeln mit Normal- und Laminar-Profilen. K. H. Gronau and K. Nickel. *DFL Inst. für. Aero. Bericht No. 56/14*, June 21, 1956. 105 pp. 10 refs. In German. Results of experimental investigations on two yawed and sweptback airfoils having normal NACA 0015 and laminar NACA 65_2-615 profiles and an aspect ratio of $\Lambda = 3$ and an angle of attack $\varphi = 45°$.

Additional Data on Surface Slopes of the RAE 100-104 Aerofoil Sections. Edna M. Love and J. Williams. *Gt. Brit., ARC CP 252*, 1956. 10 pp. BIS, New York, $0.36. Tabulation of surface shapes of RAE 100, 101, and 103 airfoil sections and additional values for RAE 102 and 104 quoted closer to the leading edge than before. An elementary but flexible method of specifying the minimum number of tangent planes needed for airfoil manufacture is given.

Method for Calculating the Aerodynamic Loading on an Oscillating Finite Wing in Subsonic and Sonic Flow. Appendix A—**Numerical Example of the Lifting-Surface Method for a Rectangular Wing.** Appendix B—**Treatment of Certain Integrals Which Contain Singularities that Arise in the Chordwise Integration.** Appendix C—**Calculation of Moment on Delta Wing.** Appendix D—**Description of a Multiple-Line Method.** Harry L. Runyan and Donald S. Woolston. *U.S., NACA TN 3694*, Aug., 1956. 76 pp. 37 refs.

Limites d'Application de la Théorie de la Ligne Portante au Calcul d'Ailes d'Avions Munies de Spoilers. A. Fauquet. *Assoc. Tech. Marit. & Aéro., Paris, Session 1956.* 12 pp. In French. Analysis of limitations in the application of the lifting-line theory to the calculation of wings equipped with spoilers.

The Optimum Aspect Ratios for Elliptical Planform Wings in Supersonic Flight. E. W. Graham and R. M. Licher. *Douglas Rep. SM-18631*, Feb., 1955. 34 pp. Analysis for determining the optimum aspect ratios in supersonic flight, using an elliptical plan form to simplify the analysis.

Experimental Investigation of the Pressure Distribution at the Centre-Section of a Sweptback Wing at High Subsonic Speeds. T. E. B. Bateman and A. J. Lawrence. *Gt. Brit., RAE Rep. Aero. 2556*, Aug., 1956. 35 pp.

The Subsonic Flow Past Swept Wings at Zero Lift Without and with Body. D. Küchemann and J. Weber. *Gt. Brit., ARC R&M 2908* (Mar., 1953), 1956. 65 pp. 25 refs. BIS, New York, $3.15. Review of the effects associated with the subsonic inviscid flow past swept wings at zero lift, with a description of methods used.

Experimentelle und theoretische Untersuchungen über den Abwind und Seitenwind hinter Pfeil- and Deltaflügeln. II—Das Seitenwindfeld. K. Gersten. *DFL Inst. für. Aero. Bericht No. 56/27*, Aug. 25, 1956. 55 pp. 20 refs. In German. Theoretical and experimental investigation of downwash and induced sidewind behind swept and delta wings.

Calculation of the Shape of a Thin Slender Wing for a Given Load Distribution and Planform. J. H. B. Smith. *Gt. Brit., RAE TN Aero.2410*, Jan., 1956. 22 pp. Calculation of the shape of a wing of given plan form necessary for producing a uniform distribution of chord loading across the span together with a chordwise lift distribution equal to that occurring in the two-dimensional flow around a flat plate.

Effet de Dièdre sur une Aile Delta en Régime Supersonique. P. Germain and D. Vallée. *La Recherche Aéronautique*, July-Aug., 1956, pp. 13–20. In French. Study of dihedral effect on delta wings in stationary supersonic flow.

Three-Dimensional Transonic Flow Theory Applied to Slender Wings and Bodies. Max A. Heaslet and John R. Spreiter. *U.S., NACA TN 3717*, July 1956. 72 pp. 32 refs. Review and comparison of transonic flow theory for slender wings and bodies of revolution with specific applications. The derivation of the integral equations for transonic flow is re-examined, giving special attention to conditions resulting from the presence of shock waves and to the reduction of the relations to the special forms necessary for analyzing the sonic flow.

The Interference Effects of a Body on the Spanwise Load Distributions of Two 45° Sweptback Wings of Aspect Ratio 8.02 from Low-Speed Tests. Appendix A—**Calculation of the Body-Induced Angle of Attack in the 19 × 1 Method.** Appendix B—**Calculation of the Body Effects by the 19 × 1 Method.** Albert P. Martina. *U.S., NACA TN 3730*, Aug., 1956. 47 pp. 18 refs. Experimental investigation of two wing-body combinations in the Langley 19-ft. pressure tunnel at a Reynolds Number of 4×10^6 and a Mach Number of 0.19 to determine the effects of wing incidence, wing fences, and flap deflection for a plane uncambered wing.

Theoretical and Experimental Investigations on Wing-Body Combinations with Delta Wings in Symmetrical Flow. K. Gersten and E. Truckenbrodt. *Braunschweig Tech. Hochschule Inst. Strömungsmech., Rep. 56/20a*, June 4, 1956. 45 pp. 25 refs. In English; translation of Bericht 56/20. ARDC-sponsored measurement of lift, drag, and pitching-moment coefficients on a delta wing carried out in combination with bodies of various lengths and longitudinal cross sections.

Reduction of Drag Due to Lift in Supersonic Flight by Distributing Lift Along a Fuselage. R. M. Licher. *J. Aero. Sci.*, Nov., 1956, pp. 1,037–1,043. Method of reducing wing drag due to lift by using a specified wing plan form and lift distribution and by determining the optimum fuselage lift distribution.

General Theory of Wave-Drag Reduction for Combinations Employing Quasi-Cylindrical Bodies with an Application to Swept-Wing and Body Combinations. Appendix A—**Pressure Field Due to Distorted Body at Any Supersonic Speed.** Appendix B—**Relationship Between Shape of Quasi-Cylindrical Body and Strengths of Axial Multipole Distributions.** Appendix C—**Alternate Method for Determining Body Shape for Minimum-Drag Combination.** Appendix D—**An Analytical Determination of Minimum-Drag Body Shape by Alternate Method.** Appendix E—**Prandtl-Glauert Transformation for Wing-Body Combination.** Jack N. Nielsen and William C. Pitts. *U.S., NACA TN 3722*, Sept., 1956. 79 pp. 12 refs.

Drag Reduction at Supersonic Speeds for Bodies of Revolution Within Cylindrical Shell Wing Systems. B. J. Beane. *Douglas Rep. SM-19411*, Nov., 1955. 15 pp. Preliminary study of the drag reductions obtained by using elliptic and rectangular cylindrical shells of zero thickness for the wing system, with a comparison of the wing-body combination with that of an isolated Sears-Haack body having the same length and volume.

Aeroelasticity

Ill-Conditioned Flutter Equations and Their Improvement for Simulator Use. E. G. Broadbent. *Gt. Brit., RAE TN Struc.195*, June, 1956. 22 pp.

Essais de Flottement d'une Maquette d'Aile. R. Landais. *Assoc. Tech. Marit. & Aéro., Paris, Session 1956.* 16 pp. In French. Results of wind-tunnel measurements for airfoil flutter investigation, using wood-metal-combination models.

Some Flutter Tests on Swept-Back Wings Using Ground-Launched Rockets. W. G. Molyneux and F. Ruddlesden. *Gt. Brit., ARC R&M 2949* (Oct., 1953), 1956. 16 pp. BIS, New York, $0.85. Results of tests on flutter models of untapered wings with 20°, 40°, and 60° sweepback and up to 1.4 Mach Number.

Flexural Vibrations of Rectangular Plates. R. D. Mindlin, A. Schacknow, and H. Deresiewicz. (*ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13–18, 1955.*) *J. Appl. Mech.*, Sept., 1956, pp. 430–436. Theoretical investigation of the influence of rotatory inertia and shear deformation of the flexural vibrations of isotropic, rectangular plates, and study of the coupling of the modes (three independent families of modes are possible when the edges are simply supported) for the case in which one pair of parallel edges is free and the other pair is simply supported. Special attention is given to the higher modes and frequencies of vibration which are beyond the range of applicability of the classical theory of thin plates.

Résultats Comparés d'Essais de Vibration au Sol par Résonance et par Percussion. H. Gauzy and G. Coupry. *La Recherche Aéronautique*, July-Aug., 1956, pp. 51, 52. In French. Comparison of results of vibration tests in flight and on the ground obtained by resonance and percussion techniques.

Longitudinal Vibrations of Composite Bar. Václav Vodička. *ZAMP*, July 25, 1956, pp. 345–349. Calculations using

Laplace transform and matrix methods to determine vibrations on a composite bar.

Some Fatigue Characteristics of a Two Spar Light Alloy Structure (Meteor 4 Tailplane). K. R. Raithby and Jennifer Longson. *Gt. Brit. ARC CP 258*, 1956. 31 pp. BIS, New York, $0.81. Experimental investigation on 61 configurations treated as representative of small-scale wing systems and tested under a variety of loading conditions, with particular attention given to determining the effects of mean load and alternating load on endurance. Results for different mean loads are in the form of endurance curves.

Fatigue Loadings in Flight Loads in the Fuselage and Nose Undercarriage of a Varsity. E. W. Wells. *Gt. Brit., RAE TN Struc.193*, May, 1956. 19 pp. Test results tabulated in terms of the number of load ranges of a given magnitude occurring during various ground and flight conditions.

Effect of Structural Flexibility on Aircraft Loading. XVI—Estimation of the Dynamic Overstress in Straight Wing Airplanes. Appendix A—**Statistical Survey of the First Bending Mode Shape of Straight Wing Airplanes.** T. H. H. Pian and P. H. Winter. *USAF WADC TR 6358*, Feb., 1954. 42 pp. Description of a simple method of solution based on the time-history of the normal acceleration of a rigid airplane. A parabolic bending deformation mode is assumed in the aerodynamic-damping estimate. Includes sample calculations.

Fatigue Loadings in Flight: Loads in the Wing of a Varsity. Anne Burns. *Gt. Brit., RAE TN Struc.192*, May, 1956. 23 pp. Flight-test data on the number of load cycles at various magnitudes during taxiing, take-off, landing, and flight in turbulence. A relationship between wing loads and accelerations in turbulence is determined, which permits the test results to be related to gust data obtained operationally by means of the counting accelerometer.

An Experimental Investigation of the Effects of Deformation on the Aerodynamic Characteristics of a Swept-Back Wing. Appendix I—**The Weissinger Method for the Prediction of Loading Due to Twist on a Swept-Back Wing.** Joseph Black. *Gt. Brit., ARC R&M 2938* (Sept., 1953), 1956. 34 pp. BIS, New York, $1.62.

Contribution au Calcul des Matrices de Rigidité. R. Kappus. *La Recherche Aéronautique*, July-Aug., 1956, pp. 43–49. In French. Calculation of rigidity matrices taking into account Thomann's formulas.

Effect of Structural Flexibility on Aircraft Loading. XIX—A Parametric Study of the Gust Response of Swept Wing Airplanes Including a Wing-Bending Degree of Freedom. Appendix A—**Digital Computation of Integrated Küssner and Wagner Functions.** Appendix B—**Solution of Two Simultaneous Triangular-Matrix Equations by a Recurrence Formula.** Appendix C—**Flexible-Wing Lift-Curve Slope.** K. A. Foss, D. Sternlight, and T. H. H. Pian. *USAF WADC TR 6358*, Mar., 1954. 49 pp.

Flambajul în Construcțiile de Avion. I. Guttman. *Rev. Transp.*, July, 1956, pp. 271–278. In Rumanian. Evaluation of the problem of buckling in bars and thin plates and application of results to the buckling problem in aircraft structures.

The Motion of an Oscillating Aerofoil in a Compressible Free Jet. D. G. Drake. *J. RAeS*, Sept., 1956, pp. 621–623. Study of the problem of supersonic and subsonic jets, using the Miles method for airfoils oscillating between wind-tunnel walls.

Analysis of Short-Period Longitudinal Oscillations of an Aircraft—Interpretation of Flight Tests. Appendix I—**Response to Typical Elevator Manoeuvres.** Appendix II—**Filtration of Experimental Oscillatory Curves.** Appendix III—**Determination of Frequency, Damping Factor, Amplitude Ratios and Phase Angles of Experimental Curves.** Appendix IV—**Remarks About the Unit of Aerodynamic Time.** Appendix V—**Alternative Analysis with Attitude Recorded Instead of Normal Acceleration; Analogy with the Case of Lateral Oscillations.** S. Neumark. *Gt. Brit., ARC R&M 2940* (Sept., 1952), 1956. 55 pp. 17 refs. BIS, New York, $2.70.

Über eine Abschätzung der Amplituden in freien Schwingungs-problemen veränderlicher Kreisfrequenz. Aurel Wintner. *ZAMP*, July 25, 1956, pp. 350–352. In German. Analysis of the effect of amplitude on the solution of a free-swinging problem of the form $x'' + \omega^2(t)\,x = 0$.

Subharmonic and Superharmonic Oscillations of a Bilinear Vibrating System. Appendix—**Numerical Values of Circuit Parameters for a Particular "Run" of the Analog.** Cyril P. Atkinson and L. O. Heflinger. *J. Franklin Inst.*, Sept., 1956, pp. 185–190. Experimental response curves of a bilinear vibrating system as produced by an electronic analog, showing the existence of superharmonic and subharmonic components in the responses, and indicating the relation of superharmonics and subharmonics with the natural frequency range of the free vibrations of the system as a possible approach to an understanding of the mechanism for the generation of harmonics.

On the Theory of the Acceleration Damper. Carl Grubin. (*ASME Natl. Appl. Mech. Conf., Urbana, June 14–16, 1956.*) *J. Appl. Mech.*, Sept., 1956, pp. 373–378. Analysis of the motion of a classical single degree of freedom system subjected to the action of a single container damper in order to determine the motion of a given system with a given damper (direct problem) and to determine the damper parameters necessary for reducing the vibration amplitude of a given system to a prescribed value (inverse problem). Two solutions are obtained for the equations governing the motion of the primary mass and the particle.

Criterii Generale Pentru Calculul Înșelitorilor Subțiri. Mircea Mihailescu. *Bul. Stiint., Sect. Stiint. Tech. Chim.*, vol. 6, 1954. 13 pp. In Rumanian. Derivation of criteria for the calculation of thin shells, based on the general integral of the differential equation of equilibrium.

Expressions for the Damping and Natural Frequency of Linear Systems. A. T. Fuller and R. H. Macmillan. *Quart. J. Mech. & Appl. Math.*, Sept., 1956, pp. 345–359. 22 refs. Derivation of three theorems concerning polynomial-equation root values by manipulation of the Routh-Hurwitz criteria. The theorems, when applied to the characteristic equation of a linear system, yield information on the dynamic constants of the dominant mode. Includes discussion of the effects on stability of the zero coefficients in the characteristic equation.

Some Aerodynamic Aspects of Gust Load Alleviation. B. J. Beane. *Douglas Rep. SM-14819*, June, 1953. 46 pp. Includes discussion of gust-load alleviation by means of streamwise gaps in the wing, analysis of a simplified model of the Douglas gust-load alleviator, analysis of the effect of aileron span on the alleviation of normal acceleration for an airplane equipped with the Douglas gust-load alleviator, and some new proposals for gust alleviation.

The Aerodynamic Force on an Airfoil in a Moving Gust. John W. Miles. *J. Aero. Sci.*, Nov., 1956, pp. 1,044–1,050. Calculation, assuming an incompressible flow, of the lift increment due to a sharp-edged gust that moves across a two-dimensional airfoil at a relative velocity different from the flight velocity.

The Pressure Distribution on an Airfoil in a Sinusoidal Gust. John W. Miles. *Douglas Rep. SM-18518*, Aug., 1954. 8 pp. Calculation of pressure distribution in terms of the complex amplitude (S) of the lift due to a unit gust.

Probability and Frequency Characteristics of Some Flight Buffet Loads. Appendix A—**Some Characteristics of a Gaussian Random Process.** Appendix B—**Numerical Filtering.** Wilber B. Huston and T. H. Skopinski. *U.S., NACA TN 3733*, Aug., 1956. 52 pp. Experimental investigation in the stall and in the shock regime of buffet loads measured on the unswept wing and tail of a fighter airplane.

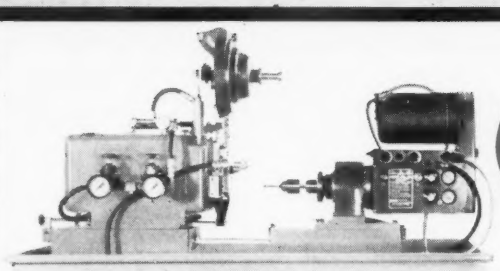
Longitudinal Response of Aircraft to Oscillatory Vertical Gusts (Frequency Analysis Including the Effect of Unsteady Aerodynamics). J. K. Zbrozek. *Gt. Brit., RAE Rep. Aero.2559*, Nov., 1955. 55 pp. 17 refs.

Models for Aero-Elastic Investigations. H. Templeton. *Gt. Brit., ARC CP 255* (Nov., 1955), 1956. 22 pp. BIS, New York, $0.63. Discussion of several types of flutter models and derivation of scale relationships for prediction models, with description of different types of construction and applications.

Vibration-Testing Techniques for Large Specimens. W. C. Schreyer and Kenneth B. Yost. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 2–6, 1956, Preprint 827.* 9 pp. Description of the Northrop electro-hydraulic vibration facility to test specimens consisting of actual aircraft structures and components.

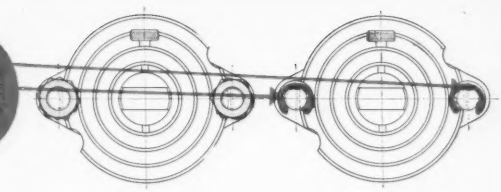
A Look at the Concept of Vibration and Noise Environmental Testing. G. L. Getline. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 2–6, 1956, Preprint 826.* 10 pp. Discussion relating the reliability of aircraft equipment to the thoroughness of the environmental test program, emphasizing the importance of being able to rationalize these tests in terms of the actual flight environment and reviewing present procedures based on flight data obtained in propeller-driven aircraft.

Waldes Truarc Retaining Rings Eliminate Machining and Parts—Cut Assembly Time on Drill and Tapper



Beco Model 410 Drill and Tapper

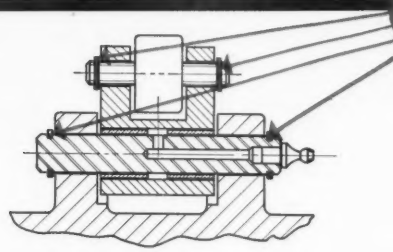
The Batchelder Engineering Co., Inc., Springfield, Vermont uses 4 different sizes of 2 different type Waldes Truarc rings in their new BECO Model 410 Automatic Drill and Tapper. Truarc rings speed assembly, reduce machining, improve design.



ALTERNATE DESIGN TRUARC DESIGN

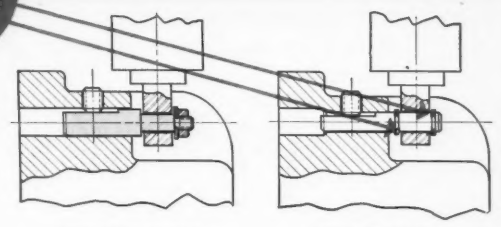
Clamp Cylinder Rod Stop Assembly

Truarc "E" Rings (Series 5133) replace stop nuts in the Clamp Cylinder assembly. They eliminate need for threading 2 rods ...the danger of cross-threading nuts...and costly rejects. Truarc Rings cut assembly time and cost.



Bell Crank Pivot Assembly

Truarc Rings (Series 5100) in Bell Crank Pivot assembly permit grease hole not possible with cotter pin fastener. Use of nuts would have increased machining and assembly costs considerably.



ALTERNATE DESIGN TRUARC DESIGN

Hopper Cylinder Anchor Pin Assembly

2 Truarc Rings (Series 5100) secure and position end of vertical air cylinder. Rings eliminate extra cost of machining 3-diameter pin, threading and undercutting... plus nut and washer. Assembly is quick and sure.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

For precision internal grooving and undercutting... Waldes Truarc Grooving Tool!

WALDES

TRUARC®

RETAINING RINGS

WALDES KOHINOOR, INC.
47-16 AUSTEL PLACE, L. I. C. 1, N. Y.

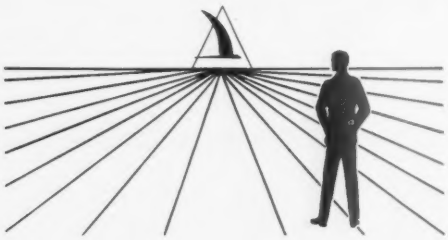
Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N.Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
(Please print)

Name .....
Title .....
Company .....
Business Address .....
City ..... Zone ..... State .....

AE128

DEPARTMENT OF TECHNOLOGY BUFFALO AND ERIE COUNTY PUBLIC LIBRA

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.



CAREERS FOR ENGINEERS

At Northrop Aircraft in Hawthorne, Southern California, many fine engineering positions are available in electrical design, dynamics, electronics, computing, weapon systems, mechanical design, and structures.

Here are many challenging opportunities, with attractive salaries on fast-growing programs in jet aircraft and guided missile research and development. You'll be on the engineering team of a company that has pioneered for over seventeen years in these fields where continued expansion promises to be fantastic.

At Northrop Aircraft, the progress of personnel is as important as the progress of projects. Your initiative and ambition will be respected. Constantly fresh assignments will be yours. You'll be among friendly people of your own caliber, and you'll be living in sunny Southern California where you and your family can enjoy life at its best, the year 'round.

At Northrop you will find the success you are seeking. For complete information about the many career positions now available, we invite you to contact the Manager of Engineering Industrial Relations, Northrop Aircraft, Inc., ORegon 8-9111, Extension 1893, or write to: 1015 East Broadway, Department 4600- Q, Hawthorne, California.

NORTHROP

NORTHROP AIRCRAFT, INC., HAWTHORNE, CALIFORNIA

Producers of Scorpion F-89 Interceptors and Snark SM-62 Intercontinental Missiles

5-A-85

Aeronautics, General

Special Issue: Britain's Aircraft Industry. *Flight*, Aug. 31, 1956. 299 pp. Directory of British 1956 aircraft and engine types, missiles, gliders, and accessory developments, with listing of producers and manufacturers.

Special Issue: British Aircraft Industry. *The Aeroplane*, Aug. 31, 1956. 383 pp. Includes specifications of current British aircraft and engine types, equipment and components, and a trade directory.

Special Issue: First S.B.A.C. Show Report. *The Aeroplane*, Sept. 7, 1956. 155 pp., cutaway drawings. Includes details of British aircraft and engine types.

Special Issue: Second S.B.A.C. Show Report. *The Aeroplane*, Sept. 14, 1956. 125 pp. Includes details of air-borne and ground equipment, engine materials, flight aids, and survival and military equipment.

World Airplane Records for Speed Altitude Distance. Peter Altman. *Auto. Ind.*, Sept. 15, 1956, pp. 70, 71, 106. Survey of airplane records in which curves are extrapolated to show future trends in aircraft performance.

Airplane Design

Three-Way Guide to British Aircraft. *Aeronautics*, Sept., 1956, pp. 100–155.

The Economics of Modern Transport Aircraft Structural Design. J. B. Edwards. *Douglas Serv.*, Sept.-Oct., 1956, pp. 11–15. Discussion of structural design as related to maintenance and operational requirements of the air lines.

The 1956 Installment of the Heater Story. T. F. Whipps. *Douglas Serv.*, Sept.-Oct., 1956, pp. 26–30. Modifications of DC-6 and DC-7 cabin heaters to improve combustion and prevent flameout at high altitudes.

Lockheed C-130A Hercules. *Flight*, Sept. 14, 1956, pp. 491–494, cutaway drawing. Description of structure, undercarriage, power plant, and fuel, electrical, flying control, hydraulic, and deicing systems.

Convair's Podded Delta. *The Aeroplane*, Sept. 21, 1956, p. 446. Description of the new Convair B-58 Hustler, a four-jet delta-wing design with all four engines podded and the outboard pair mounted close under the wings near the tips. Nacelle and wing plan-form features are discussed in detail.

Vanguard—"Two Airliners in One." James Hay Stevens. *Vickers Mag.*, Summer, 1956, pp. 23–27. Design and structural characteristics of Vickers air liners; includes description of power plants and systems.

Announcing the Comet 4A. *de Havilland Gazette*, Aug., 1956, pp. 100–104. Design and performance characteristics of a short-haul and medium-haul version of the de Havilland air liner.

Self-Sufficiency is Key to C-133A Design. Irwin Stambler. *Av. Age*, Sept., 1956, pp. 20, 21, 22–25 ff. Design and structural characteristics of Douglas transport. Includes details of a self-sufficient system for generating the plane's own hydraulic and electric power while on the ground.

ATTENTION!

AIRCRAFT PARTS & EQUIPMENT MANUFACTURERS

Order Space Now

in the

1957 AERONAUTICAL ENGINEERING CATALOG

"Aviation's Established Buyer's Guide and Directory"

7,000 distribution in March, 1957, to Buyer's and Buying Engineers in Aircraft Plants . . . Engine Plants . . . Air Force . . . NACA . . . Navy . . . Wind Tunnels . . . Research Laboratories . . . . Major Airlines.

Write today for details and 4-Page Specifications Folder

Deadline for copy—Dec. 17, 1956

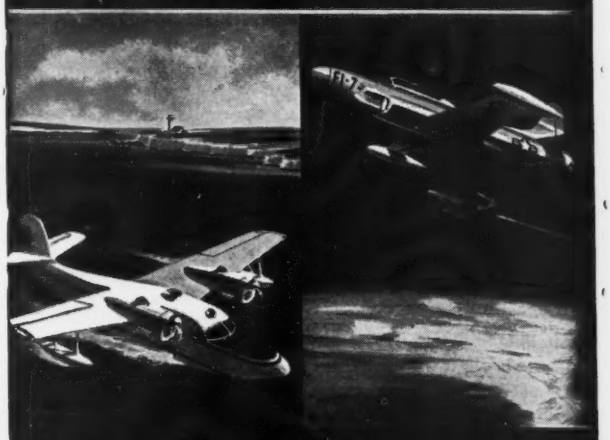
AERONAUTICAL ENGINEERING CATALOG

Published by

Institute of the Aeronautical Sciences

2 East 64th St. New York 21, N.Y.

From Water Level To Stratosphere...



Pittsburgh FABSEAL

Makes Flying Safer... More Efficient!

Millions of flying hours prove the dependable performance of these impregnated fabric tapes in civilian and military use!

● Many of America's leading builders of aircraft use Pittsburgh's FABSEAL Tapes with complete confidence in their outstanding quality to seal flying boats, pressurized cabins and for other applications where there is considerable racking movement.

● FABSEAL Tapes are impregnated fabric of uniform density, resistant to water, gasoline and oil. They are available in .015" thickness and in widths from ½" to 12", packages in rolls of 50 feet.

● These tapes are particularly designed for use in fluid or air containers where excessive pressures are experienced. They are also adapted for sealing structural members where flexibility and vibration present unusual requirements. FABSEAL Tapes can also be bolted, riveted or screwed between metal, wood or fiber members to provide a fillet that assures a complete seal.

● Call on us for advisory service. Our wide experience in the aircraft field often can save you time and money.

PITTSBURGH PLATE GLASS CO., Industrial Paint Div., Pittsburgh, Pa. Factories: Milwaukee, Wis.; Newark, N. J.; Springdale, Pa.; Houston, Texas, Los Angeles, Calif.; Portland, Ore. Ditzler Color Div., Detroit, Michigan. The Thresher Paint & Varnish Co., Dayton, Ohio. Forbes Finishes Division, Cleveland, Ohio. M. B. Suydam Div., Pittsburgh, Pa.

PITTSBURGH PAINTS

PAINTS • GLASS • CHEMICALS • BRUSHES • PLASTICS • FIBER GLASS

PITTSBURGH PLATE GLASS COMPANY

Avion SE. 210 "Caravelle." J. Dor. *Assoc. Tech. Marit. & Aéro., Paris, Session 1956.* 11 pp. In French. Design evaluation of the SE. 210 "Caravelle" in terms of its aerodynamic, propulsion, and safety systems and of its application in air transport operation.

French Interceptor Combines Jet and Rocket Power. Walter P. Moser. *Av. Age,* Sept., 1956, pp. 48, 49, 50–53 ff. Design characteristics of SNCASO "Trident" with emphasis on the dual powerplant configuration.

The Structure of the Comet. *de Havilland Gazette,* Aug., 1956, pp. 121–124, cutaway drawing. Discussion of test program and structural characteristics of a de Havilland air liner.

Air Conditioning & Pressurization

Air-Conditioning and Pressurization Equipment Requirements for High Performance Flight. A. R. Perl and J. Hall Hood. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 2–6, 1956, Preprint 823.* 6 pp.

Cockpits

Design, Fabrication and Test of Laminated Paned Canopy Section. M. C. Wardle. *USAF WADC TR 54-395,* May, 1954. 68 pp. Experimental investigation of a specimen section, two panels long by two panels wide, under standard conditions for hot-soak, cold-soak, ambient pressure, and pressure-cycling tests.

Integrated Instrument System Makes Cockpit Capsule Possible. Irwin Stambler. *Av. Age,* Oct., 1956, pp. 34, 35, 36–39 ff. Progress report on the Army-ONR-Douglas-BuAer Program to design a complete man-machine system, starting from a re-evaluation of all pertinent principles in order to develop a new set of fundamental concepts to make such a design feasible.

Fuel Tanks

Integral Fuel-Tank. *Aircraft Prod.,* Oct., 1956, pp. 420–425. Description of resistance-welding techniques used in the construction of a leading-edge integral fuel tank for the Cougar fighter.

Landing Gear

Nose Gear Structural Experience; DC-6, DC-7 Series. R. G. Dempsey. *Douglas Serv.,* Sept.-Oct., 1956, pp. 16–25. Review of the nose gear structure from the standpoint of service problems encountered and the corrective action taken to alleviate these difficulties.

Operation & Performance

Range and Weight Limits of Modern Transport Aircraft. G. V. Lachmann. *Handley-Page Bul.,* Autumn, 1956, pp. 4–9. Discussion of gross weight versus stage range for large, fast transport aircraft. Several types are compared, and a detailed analysis is presented for a laminar-flow aircraft of 190,000 lbs., with a stage of 3,000 nautical-miles, when cruising at 435 knots. It is shown that, as speed increases, the stage range and pay load decrease rapidly.

Pilot's Report: F-27 Friendship Turboprop. Frank H. Hawkins. *Av. Age,* Oct., 1956, pp. 220–223 ff.

Britannia Economics on Short Hauls. *Bristol Quart.,* Summer, 1956, pp. 40–43. Study of operating costs for the Bristol Britannia within 200–1,600-mile range.

Some Maintenance Aspects of Viscount Operation. E. R. Major. *J. RAeS,* Sept., 1956, pp. 605–617. Discussion, based on British European Airways' maintenance cost figures, to emphasize the need for reducing such costs—particularly those arising from unscheduled maintenance—to a minimum.

Progress with the Herald. *Handley-Page Bul.,* Autumn, 1956, pp. 12–19. Design, structural, and performance characteristics of the Handley-Page Herald. Includes discussion of flying qualities and serviceability.

Windshields

Plastic Pressure Cabins: A Critical Assessment of the Suitability of Fibre-Reinforced Plastics for Pressurized Fuselage Structures. P. B. Walker. *Aircraft Eng.,* Sept., 1956, pp. 322–324.

Airports

Stadiul Actual al Technicii Îmbrăcăminților de Drumuri și Piste din Beton de Ciment. I. E. Focsanu. *Rev. Transp.,* July, 1956, pp. 268–271. In Rumanian. Evaluation of techniques used since 1950 for concrete runways.

Aviation Medicine

Human Engineering

A Technique for Displaying Task Analysis Information. Robert L. Weislogel and T. Owen Jacobs. *USAF SWC TN 56-11,* Mar., 1956. 6 pp. Description of a method involving the establishment of a matrix of job activities on a base page and the use of a series of especially pre-printed overlay pages of transparent plastic to present the various psychological and manipulative demands made upon the operator in accomplishing the sequences of job requirements in proper alignment with these jobs.

Computers

IRE Standards on Electronic Computers: Definitions of Terms, 1956. L. C. Hobbs, N. Rochester, W. H. Ware, R. Serrell, M. W. Baldwin, Jr., and others. *Proc. IRE,* Sept., 1956, pp. 1,166–1,173.

Design of Computer Circuits for Reliability. W. Renwick. *Electronic Eng.,* Sept., 1956, pp. 380–384. 10 refs. Discussion of reliability precautions to be taken during initial circuit design, including the mechanical construction and the choice of components.

Automatic Data Reduction. Martin L. Klein, Frank K. Williams, and Harry C. Morgan. *Instruments & Automation,* Sept., 1956, pp. 1,767–1,772. Discussion of a data-reduction system and its advantages in handling large quantities of material. A sample system is analyzed, and it is shown to be essentially the feedback loop of a digital automation system. By proper design the system can be expanded to control the process automatically.

Standard Deviation of Dead Time Correction in Counters. L. Lorne Campbell. *Can. J. Phys.,* Sept., 1956, pp. 929–937. Description of a method of deriving asymptotic expressions for the deviation of random events and for the *m*th moment of the number of registrations occurring during the time of observation. The method is also applicable for determining asymptotic expressions for the expected values of other functions of the number of registrations.

The Analysis of Stationary Time Series. II—Estimation of Power Spectra. M. B. Priestley. *Gt. Brit., RAE TN M.S.29,* June, 1956. 18 pp. Description of methods for estimating the spectral density, integrated spectrum, and band spectrum of a discrete stationary time series, and details of DEUCE programs which compute estimates of these functions by using, in each case, three different weighting functions.

Data Transmission by Synchros. F. G. Helps. *Electronic Eng.,* Oct., 1956, pp. 438–445. 21 refs. Consideration of various types of synchros and the factors influencing their accuracy in both their application to transmission problems and their design and manufacture, and description of circuits for obtaining the "electrical zero" reference position and for testing synchros. Synchros are used for the electrical transmission of the position of a rotating shaft and for computing purposes.

Computing Device for Water Content of Gases. *U.S., NBS Sum. TR 2044,* Sept., 1956. 3 pp. Development of a simple hand computer of the circular slide rule type which is faster, more accurate, and less expensive than previous devices for this purpose.

An Electronic Analogue Computer. Appendix I—Analysis of the Computer Operations. Appendix II—Theory of Computational Accuracy. Appendix III—Measuring Methods. Appendix IV—Transfer Function Networks. D. E. Hatton and J. R. Ward. *Australia, Aero. Res. Comm. Rep. ACA-57,* Sept., 1955. 34 pp. Description of a general-purpose instrument for research work in dynamics, with particular reference to the study of servomechanisms and aircraft stability. Includes a detailed evaluation of analog-computer theory.

Airborne Analogue Computer Plots Aircraft's Own Position on a Mercator Chart. T. A. Westover. *AIEE South West District Meeting, Dallas, Apr. 2–4, 1956, Paper.* Discussion of the fundamental electrical design, instrumentation, and physical features of an electro-mechanical computer.

Transistor-Magnetic Analog Multiplier. Glenn L. Keister. *Electronics,* Oct., 1956, pp. 160–163. Description of an instrument which is capable of performing four-quadrant multiplication and in which one input variable controls amplitude of a square wave while a second variable governs the phase, with multiplication of variables accomplished by averaging the resulting square wave, in order to achieve linearity within 3 per cent with 10 deg. phase shift at 100 cps.

Photoelectric Analog Function Generator. Robert A. Sinker. *Electronics,* Oct.,

Because
HIS LIFE
depends on it...

. . . Nothing is left undone to make the Relief Valve in the fuel pump, the *Safest,* the most *Dependable,* the *Lightest* valve possible with today's skills and materials.

Fluid Regulators Corp. is a Major Designer and Producer of Relief Valves for jet fuel pumps.

Designers and Producers of Aircraft Hydraulic and Fuel Valves.

Fluid Regulators
CORPORATION
250 E. MAIN STREET • PAINESVILLE, OHIO

1956, pp. 178–181. Description of an instrument which achieves satisfactory accuracy by incorporating a gray-scale standard deflection feedback loop and an intensity servo feedback loop, both used with a second beam of light in a nulling correction arrangement.

Tying System Hardware to Analog Computers for Simulated Flight Tests. W. L. Evans. *Av. Age*, Sept., 1956, pp. 42, 43, 44–47 ff. Description of systems where flight testing is simulated by ground tests in which actual equipment is tied into closed loops with analog computers.

The G-15 Digital Computer. S. Herbert Lewis. *Instruments & Automation*, Sept., 1956, pp. 1,773–1,779. Discussion of the principles, operation, and application of a general-purpose digital computer of moderate size.

Education & Training

The Aviation Mechanic Testing Program in the Operational Commands. Howard J. Hausman and Joseph F. Morsh. *USAF PTRC TN 56-53*, May, 1956. 18 pp. 19 refs.

Introduction to Jet Flight. F. M. O'Connor. *Aircraft* (Canada), Sept., 1956, pp. 20–22, 25–28, 75–77 ff. Study of the advantages of a jet primary trainer.

Flight Application of Target-Simulator Principles. William M. Kauffman. (*IAS Natl. Summer Meeting, Los Angeles, June 18–21, 1956, Preprint 649*). *Aero. Eng. Rev.*, Nov., 1956, pp. 76–80.

Early Flight—An Aircraft Simulator for Investigations of Handling Characteristics. A. B. Johnson. *Saro Prog.*, Autumn, 1956, pp. 10, 11. Description of the Saunders-Roe Aircraft Simulator.

Comparison of Performance upon the E-4 Fire Control System Simulator and upon Operational Equipment. Guy G. Besnard and Leslie J. Briggs. *USAF PTRC TN 56-47*, Apr., 1956. 15 pp. Study to determine the extent to which a student's performance of selected maintenance procedures in the E-4 fire control system procedural simulator is similar to the performance of these tasks on an operating fire control system.

A Troubleshooting Trainer for the E-4 Fire Control System. Leslie J. Briggs. *USAF PTRC TN 56-94*, July, 1956. 12 pp.

The Construction of Spatial Orientation Items by Means of a Cyclorama. Frederick B. Davis. *USAF PTRC TN 56-61*, June, 1956. 16 pp. Development of a cyclorama for simulating aerial photographs as an aid in aircrew selection tests.

Electronics

Reliability Indices for Missile Electronic Component Parts. Thomas S. Bills. *Electronic Appl. Rel. Rev.*, Sept., 1956, pp. 3–7.

New Developments in Radio and Radar. *Flight*, Sept. 21, 1956, pp. 511–513. Survey of electrical equipment presented at the SBAC show.

Electronic Circuitry. Charles F. Kezer and Milton H. Aronson. *Instruments & Automation*, Sept., 1956, pp. 1,780, 1,781. Includes transistor servo-preamplifier using transformer coupling, r.c.-coupled and direct-coupled transistor amplifier, and gamma monitor identifying and evaluating activity.

The Embedding of Soft Magnetic Materials in Plastics. R. Boll. (*ETZ*, July 11, 1956, pp. 483–487.) *Engr. Dig.*, Sept., 1956, pp. 375, 376. Discussion showing how to avoid mechanical stresses occurring when high-grade magnetic cores are embedded in synthetic materials or, alternatively, how to make use of such stresses to obtain improved magnetic properties.

Taking the Heat Off Miniature Equipment. James P. Welsh. *Electronics*, Oct., 1956, pp. 152–156. Discussion of electronic cooling covering the rating of parts and equipment, and various cooling methods including sealed units and liquid cooling.

Dependence of the Dielectric Strength of Some Alkali Halide Monocrystals on the Duration of the Applied Voltage. G. A. Vorob'ev. (*Zhurnal Eperimental'noi i Teoreticheskoi Fisiki*, Feb., 1956, pp. 256–261.) *Soviet Physics—JETP*, Sept., 1956, pp. 225–229. 12 refs. Translation.

Impedance Transformers. Appendix I—**Reflection Pattern for Straight Taper of the Centre Conductor.** Appendix II—**Effect of Attenuation.** J. Willis and N. K. Sinha. *Wireless Engr.*, Sept., 1956, pp. 204–208. 15 refs. Results of experiments using nonuniform tapered lines as impedance transformers. Reflection patterns for two types of tapered line are obtained and compared with the theoretical patterns.

Propagation of Microwaves Along a Solid Conductor Embedded in Three Coaxial Dielectrics. S. K. Chatterjee and R. Chatterjee. *J. Indian Inst. Sci., Sect. B*, July, 1956, pp. 157–171.

Über eine anschauliche Darstellung der Vorgänge bei der Fortpflanzung von unstetigen Signalen in Wellenleitern. Adalbert Rubinowicz. *ZAMP*, July 25, 1956, pp. 316–325. In German. Analysis of the propagation of a cut-off periodic wave, first for any section of the wave guide and then for a rectangular section.

Amplifiers

Current Reference for Magnetic Amplifiers. D. A. Burt. *Tele-Tech.* Oct., 1956, pp. 66, 67, 136, 138–145 ff.

Transistor Pulse Regenerative Amplifiers. F. H. Tendick, Jr. *Bell System Tech. J.*, Sept., 1956, pp. 1,085–1,114. 13 refs. Description of design techniques for synchronized regenerative amplifiers operating at a pulse-repetition rate of the order of 1 mc./sec., with an illustrative example of the design of an amplifier for use in a specific digital computer.

Transistor R. F. Amplifiers. I—Available Junction Types as High Frequency Circuit Elements. D. D. Jones. *Wireless World*, Oct., 1956, pp. 494–496.

Antennas

A 60-Foot Diameter Parabolic Antenna for Propagation Studies. A. B. Crawford, H. T. Friis, and W. C. Jakes, Jr. *Bell System Tech. J.*, Sept., 1956, pp. 1,199–1,208. ARDC-supported design of the aluminum-constructed, solid-surface antenna, which can be steered in azimuth and elevation and is especially designed for studies of beyond-the-horizon radio propagation at frequencies of 460 mc. and 4,000 mc. Includes details of the antenna's electrical and mechanical properties, its construction, and the pertinent measurement technique.

Les Antennes Encastrées à Bord des Avions. F. Babin. *Assoc. Tech. Marit. & Aéro., Paris, Session 1956.* 32 pp. In French. Discussion of the advantages of built-in antennas for high-speed aircraft application.

Concerning the Orientation of the Antenna of an Ionosphere Station. Z. Ts. Rapoport. (*Zhurnal Experimental'noi i Teoreticheskoi Fisiki*, Feb., 1956, pp. 407–408.) *Soviet Physics—JETP*, Sept., 1956, pp. 296, 297. Translation. Theoretical investigation based on the fact that two waves appear in the incidence of an electromagnetic wave upon the lower boundary of the ionosphere and that the sum of their intensities yields that of the incident wave.

Electronic Tubes

Investigation at Low Gas Pressure of an Intermediate Frequency Discharge Occurring Between High Frequency and Low Audio Frequency Discharges. N. A. Popov and N. A. Kaptsov. (*Zhurnal Experimental'noi i Teoreticheskoi Fisiki*, Jan., 1956, pp. 68–76.) *Soviet Physics—JETP*, Sept., 1956, pp. 147–155. 16 refs. Translation.

Polar Co-Ordinate Oscilloscopes. G. F. Craven. *Electronic Eng.*, Oct., 1956, pp. 422–425. Description of methods for generating a circular time-base and of circuits for radial modulation, with examples of the application of polar coordinates and with reference to the use of a Magslip transmitter as the time-base generator.

Instability in Hollow and Strip Electron Beams. C. C. Cutler. *J. Appl. Phys.*, Sept., 1956, pp. 1,028, 1,029.

The Design of Cold-Cathode Valve Circuits. I. J. E. Flood and J. B. Warman. *Electronic Eng.*, Oct., 1956, pp. 416–421. 12 refs. Discussion covering the characteristics of diodes and triodes and the limits they impose on circuit design; basic methods for operating and extinguishing cold-cathode valves; circuit elements for performing logical operations, counting, and information storage; the effects of tolerances on circuit operation and method for obtaining adequate circuit margins; multicathode valve circuits; and the use of cold-cathode valves in practical equipment.

Photographing High Frequency Cathode Ray Tube Traces. E. S. Mallett and H. W. P. Knapp. *Gt. Brit., MOS TN T.D.5*, Feb., 1956. 12 pp. Description of a method for increasing the effective film velocity by movement of the cathode-ray tube trace and for improving the clarity and resolution of the trace by brilliance modulation.

Magnetic Devices

Interrelation Between the Anisotropy of the Hall Effect and the Change in Resistance of Metals in a Magnetic Field. I—Investigation of Zinc. E. S. Borovik. (*Zhurnal Experimental'noi i Teoreticheskoi Fisiki*, 1956, pp. 262–271.) *Soviet Physics—JETP*, Sept., 1956, pp. 243–251. 21 refs. Translation.

Fairchild Operations Engineers, Plez P. Moody and Robert A. Booth study aspects of a carrier-on-board delivery plan involving the C-123 assault and logistics transport.

OPERATIONS ENGINEERS

The Operations Engineering Section of the Projects Administration Department of Fairchild Aircraft Division offers opportunities for graduate engineers capable of conducting aircraft utilization analysis.

These assignments require knowledge of and experience in:

- **Airworthiness Requirements**
- **Performance Analysis**
- **Power Plant Specifications**
- **Route and Mission Determination**

At the present time, these assignments relate to the Fairchild C-123 cargo transport, the Fairchild Friendship turboprop passenger transport, and the Fairchild M-185 jet utility transport.

The opportunities and salaries associated with the new positions are commensurate with the responsibilities of the work. Employee benefits in the form of group insurance, individual and family coverage for hospitalization, retirement plan, sick leave, etc., are also provided.

Send complete resume of education and experience,
together with salary requirements to:
EMPLOYMENT MANAGER – P.O. BOX 134

...WHERE THE FUTURE IS MEASURED IN LIGHT-YEARS!

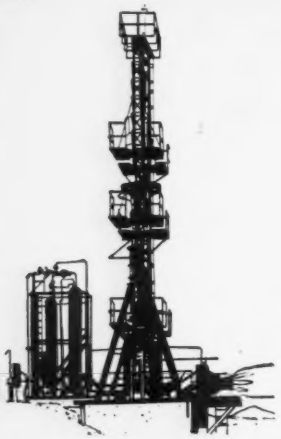
FAIRCHILD

AIRCRAFT DIVISION • HAGERSTOWN 10, MARYLAND

A Division of Fairchild Engine and Airplane Corporation

LIQUID ENGINE DIVISION

In piloted aircraft, missiles, and upper-atmosphere research vehicles, Aerojet-General liquid-propellant rockets have proven unexcelled for assisted takeoff, superperformance, and as prime power-plants.



Whether your interest lies in Vanguard or valves, Aerojet-General offers a variety of challenging assignments for:

Mechanical Engineers
Electronic Engineers
Chemical Engineers
Electrical Engineers
Aeronautical Engineers
Civil Engineers
Metallurgists
Chemists
Physicists
Mathematicians
Technical Editors

Aerojet-General
CORPORATION
A Subsidiary of The General Tire & Rubber Company
THE GENERAL TIRE
PLANTS AT AZUSA AND NEAR SACRAMENTO, CALIFORNIA

Write: Director of Scientific and Engineering Personnel, Box 296C, Azusa, Calif. or Box 1947C, Sacramento, Calif.

Amplitude Modulation of Centimetre Waves by Means of Ferroxcube. H. G. Beljers. *Philips Tech. Rev.*, No. 3, 1956–1957, pp. 82–86. Description of a modulation method involving the fitting of a small ferroxcube rod into a cylindrical cavity resonator at a point where the alternating magnetic field is strong, and the fixing of coils around the rod in order to excite the modulating magnetic field in the axial direction. An analysis is included to show that the saturation magnetization of the ferroxcube determines the highest carrier frequency at which absorption modulation is possible.

Investigations on Barium Ferrite Magnets. K. J. Sixtus, K. J. Kronenberg, and R. K. Tenzer. *J. Appl. Phys.*, Sept., 1956, pp. 1,051–1,057. 11 refs. WADC-sponsored study of barium ferrite for testing the predictions of fine particle theory in the region of grain sizes larger than the critical one and for which no satisfactory theory exists as yet.

An Investigation of Magnetic Spectra of Solid Solutions of Some NiZn-Ferrites in the Radiofrequency Range. L. A. Fomenko. (*Zhurnal Experimental'noi i Teoreticheskoi Fisiki*, Jan., 1956, pp. 18–29.) *Soviet Physics—JETP*, Aug., 1956, pp. 19–28. 31 refs. Translation. Experimental investigation of the magnetic spectra of several types of NiZn ferrites in the demagnetized state, in a state of residual magnetization, and at various values of intensity of the constant magnetizing field. Includes examination of the method of measuring the spectra and of eliminating possible inaccuracies in the results.

Networks

The Analysis of Three-Terminal Null Networks. T. H. O'Dell. *Electronic Eng.*, Sept., 1956, pp. 398–400. Description of a simplified method to derive an expression for the output voltage after only four operations.

A Time-Dependent Nonlinear Compensating Network. J. C. Clegg. *Elec. Eng.*, Oct., 1956, pp. 898. Abridged. Brief description of a system which accommodates different magnitudes of step inputs without adjustment because the charge acquired by either capacitor is proportional to the input.

Restrictions on the Shape Factors of the Step Response of Positive Real System Functions. Armen H. Zemanian. *Proc. IRE*, Sept., 1956, pp. 1,160–1,165. Development of a lower bound on the rise time from zero to the final value for the step response of a network whose system function is positive real.

Noise & Interference

Noise Measurements in the 3-cm Waveband Using a Hot Source. H. Sutcliffe. *Proc. IEE, Part B*, Sept., 1956, pp. 673–677. 13 refs. Description of a method involving the use of the noise power produced in a wave-guide termination at temperatures up to 600°C. as a standard of low-level power, and of a suitable type of hot source and associated wave-guide and detecting circuits. Includes measurement data on the effective temperature of a gas-discharge tube used as a secondary standard source.

Minimum Signal Distortion and Noise Power in Linear Filters. R. Kulikowski. *Bul. Acad. Polonaise Sci.* (Warsaw), No. 2, 1956, pp. 123–126. Development of equations for designing a specific filtering system which will transfer signals containing random and nonrandom components with minimum distortion.

Absolute Calibration of a Standard Temperature Noise Source for Use with S-Band Radiometers. V. A. Hughes. *Proc. IEE, Part B*, Sept., 1956, pp. 669–672. Experimental investigation of the argon discharge tube CV1881 in an E-plane mount at 2,860 mc./sec.

Notes on a Source of Intermittent Noise in Oxide-Cathode Receiving Valves. M. R. Child. *Proc. IEE, Part B*, Sept., 1956, pp. 667, 668. Identification of a noise source with the presence of variable-leakage paths between certain electrodes; discussion of the dependence of this phenomenon on valve parameters; and description of an improvement in valve design which inhibits the growth of interelectrode leakage.

Performance and Design of Low-Noise Guns for Traveling-Wave Tubes. R. C. Knechtli and W. R. Beam. *RCA Rev.*, Sept., 1956, pp. 410–424. Discussion of factors determining the performance of low-noise guns in microwave beam amplifiers. Also includes systematic measurements on a three-region low-noise gun and directions for optimum choice of gun design parameters.

Oscillators & Signal Generators

Oscillator Frequency Stability. A. S. Gladwin. *Wireless Engr.*, Sept., 1956 pp. 209–220. 11 refs. Development of a basic theory for stability criteria for various circuit arrangements, considering hysteresis effects in a mismatched load through a long feeder and periodic modulation when the load is a resonant circuit.

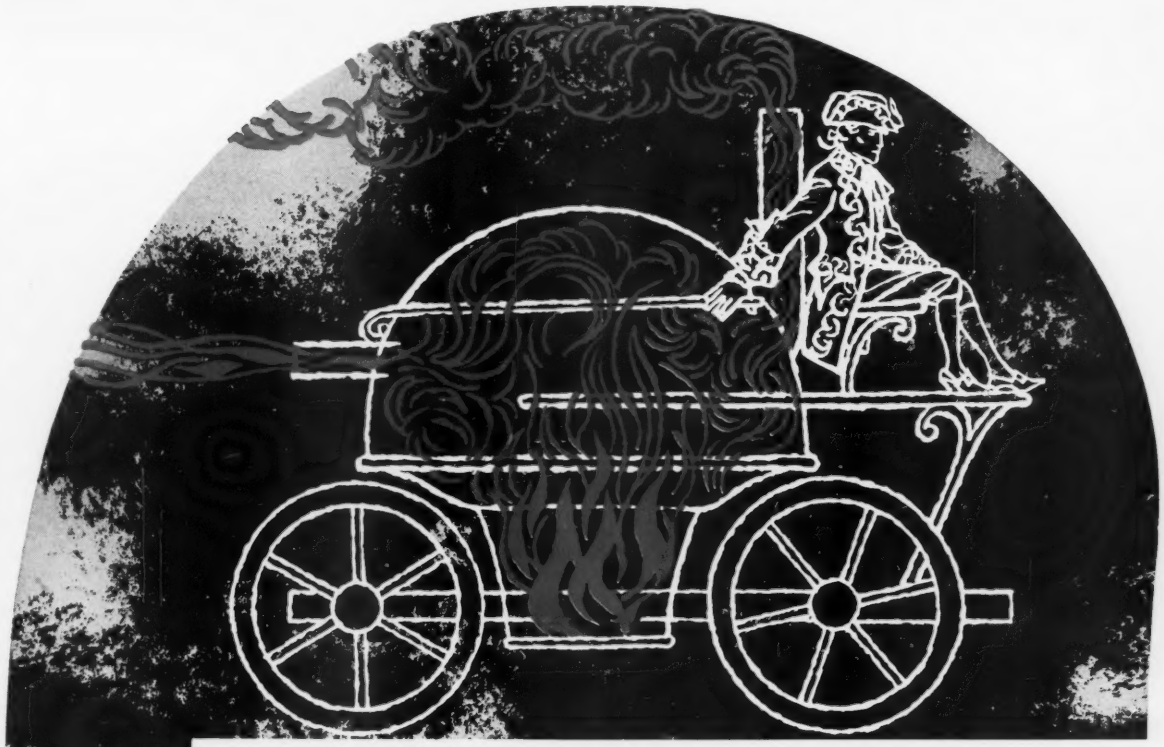
An 8-mm Klystron Power Oscillator. R. L. Bell and M. Hillier. *Proc. IRE*, Sept., 1956, pp. 1,155–1,159. Development of a cw klystron oscillator as a low-noise transmitter for the 8-mm. band, with details of its performance.

Phase Generator for Tropospheric Research. R. W. Hubbard and M. C. Thompson, Jr. *Electronics*, Oct., 1956, pp. 220–223. Description of a laboratory-standard instrument which provides phase-displaced signals, either pulses or sinusoids, for checking and calibrating phase-shifting networks, oscilloscope sweeps, phase meters, and other instruments where separation of periodic signals is important.

Radar

Smallest Airborne Weather Radar Yet for Light Twins. James Holahan. *Av. Age*, Oct., 1956, pp. 80, 81, 82–85 ff. Description of RCA's new 50-lb. AVQ-50 radar which has resolved sweep, short CRT, a 12-in. reflector, and tubeless power supplies.

Maximum Angular Accuracy of a Pulsed Search Radar. Peter Swerling. *Proc. IRE*, Sept., 1956, pp. 1,146–1,155. Investigation of the limits imposed by the receiver noise on the accuracy with which angular position of a target can be determined by a pulsed search radar.



s'Gravesande's Stoomwagen

s'Gravesande's Steam Reaction Car

In 1721 Jacob Willem s'Gravesande of Delft, stimulated by the recently enunciated Third Law of Motion, astounded the Royal Society by constructing a practical steam reaction car. The vehicle actually moved several times its own length, a distance of about two meters.

In 1956 the goal is no longer meters, but hundreds, and even thousands, of miles. Aerojet-General Corporation, leader in American rocket propulsion for more than a decade, is proud to participate in man's first assault on the frontiers of outer space—Project Vanguard.

Aerojet-General CORPORATION

A Subsidiary of The General Tire & Rubber Company

AZUSA, CALIFORNIA
SACRAMENTO, CALIFORNIA

Aerojet-General invites scientists and engineers—men of imagination and vision—to join the attack on the most significant research, development and production problems of our time.

A Precise New System of FM Radar. Mohamed A. W. Ismail. *Proc. IRE*, Sept. 1956, pp. 1,140–1,145. Analysis of a radar system in which both the range and the speed of the target can be accurately measured. The "fixed error," which is characteristic of most FM radar, has been eliminated.

Radar Simulator for Laboratory Use. Henry J. Bickel and Robert I. Bernstein. *Electronics*, Oct., 1956, pp. 170–173. Description of equipment which provides a simulated search radar output having the same statistical and systematic characteristics as those obtained from a real radar receiving echoes from a flying target.

Measuring Rate-of-Climb by Doppler Radar. S. H. Logue. *Tele-Tech*, Oct., 1956, pp. 74, 75, 146–149 ff. Description of the Magic Tee unit designed for Navy's Pogo-Stick fighter and using doppler effect for accurate indication of vertical velocity.

Semiconductors

Transistors and Diodes Stabilize A-C Servos. R. Gittleman. *Electronics*, Oct., 1956, pp. 174, 175.

Checking DC Parameters of Transistors. M. E. Jones and J. R. MacDonald. *Tele-Tech*, Oct., 1956, pp. 56–58.

Transit Time Transistor. Gabriel Weinreich. *J. Appl. Phys.*, Sept., 1956, pp. 1,025–1,027. Analysis showing that by utilizing transit-time effects an appropriately designed transistor can be operated as a three-terminal amplifier in certain special frequency bands.

P-N-P-N Transistor Switches. J. L. Moll, M. Tanenbaum, J. M. Goldey, and N. Holonyak. *Proc. IRE*, Sept., 1956, pp. 1,174–1,182. 12 refs. Design, fabrication, and electrical characteristics of p-n-p-n transistors with a temperature resistance coefficient greater than one for use as switches.

Transistorized Binary Pulse Regenerator. L. R. Wrathall. *Bell System Tech. J.*, Sept., 1956, pp. 1,059–1,084. Description of the construction of a simple transistorized device for amplifying and regenerating binary code signals as they are transmitted over substantial lengths of transmission line, and discussion of the theory of the circuit, with measured results and oscillograms showing its performance. Includes the effects of extraneous interference on the production of errors of such a repeater.

Two-Terminal P-N Junction Devices for Frequency Conversion and Computation. Arthur Uhlir, Jr. *Proc. IRE*, Sept., 1956, pp. 1,183–1,191. 19 refs. Analysis to determine design principles for semiconductor diodes from idealized p-n junctions. The superheterodyne conversion matrix and large-signal admittance are given in terms of the small-signal diffusion admittances.

Combined Measurements of Field Effect, Surface Photo-Voltage and Photoconductivity. W. H. Brattain and C. G. B. Garrett. *Bell System Tech. J.*, Sept., 1956, pp. 1,019–1,040. 12 refs.

Distribution and Cross-Sections of Fast States on Germanium Surfaces. C. G. B. Garrett and W. H. Brattain. *Bell System Tech. J.*, Sept., 1956, pp. 1,041–1,058. 17 refs.

Equipment

Electric

Electric Equipment Problems in Supersonic Vehicles. Victor B. Hart. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 2–6, 1956, Preprint 821.* 16 pp. Discussion of environmental conditions encountered in supersonic flight and of new requirements imposed on electrical materials and equipment.

High-Temperature Components. G. W. A. Dummer. *Wireless World*, Oct., 1956, pp. 510–512. Review of construction techniques and component developments for electrical equipment subject to high temperatures.

Hydraulic & Pneumatic

Analysis of a Hydraulic Servo Using a Pressure Control Valve. R. R. Berlot. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 2–6, 1956, Preprint 837.* 17 pp. Includes determination of the parametric dependence of the system transfer function and comparison with that for a flow control valve working into the same load.

Hydraulic and Pneumatic Problems in High Performance Aircraft. Ralph E. Middleton. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 2–6, 1956, Preprint 822.* 6 pp. Discussion of design problems in hydraulic and pneumatic systems induced by high-temperature operation.

Stresses in Shock Absorbers. N. J. Durant. *J. RAeS*, Sept., 1956, pp. 618, 619. Investigation of stresses in hollow circular cylinders of constant wall thickness and closed by flexible plates. The cylinder is subjected to the combined action of an internal pressure and an axial force, both applied statically.

Load Limiting Devices for Retractable Aircraft Cylinders. P. Person. *Appl. Hydraulics*, Sept., 1956, pp. 106, 108, 110, 112, 114. Description of a device for minimizing the effects of pressure loads which a jack exerts over the last movement of travel to the extended or closed position.

Flight Operating Problems

Problems of Trans-Polar Operations. Knut Jonn. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 2–6, 1956, Preprint 825.* 10 pp. Historical review and discussion covering conditions peculiar to arctic aviation, the main difficulties of navigation including the convergence of the meridiane and isogones, the limited use of the magnetic compass, the twilight periods, and the lack of radio navigational aids, radio communications, weather operation, and rescue facilities.

Flight Testing

Fatigue Loadings in Flight: Loads in the Tailplane and Fin of a Varsity. Anne Burns. *Gt. Brit., ARC CP 256* (Jan., 1956), 1956. 20 pp. BIS, New York, $0.63. Investigation of load cycles in normal ground and flight conditions, which include flight in turbulence, take-off, landing, taxiing, and ground running of the engines. Discussion includes description of instrumentation and flight tests, and estimation of load occurrences in typical flight.

Fuels & Lubricants

Lubrication Systems for High-Performance Ball Bearings. T. E. Rounds. *Mach. Des.*, Sept. 20, 1956, pp. 114–120.

Some Measurements of the Volatility of Synthetic Lubricants. D. J. Barke and G. Kinner. *Gt. Brit., RAE TN Chem. 1282*, June, 1956. 14 pp. Tests using three separate methods, with results indicating that only the ASTM evaporation cell method gives satisfactorily precise data. Includes a qualitative explanation of the behavior of the ASTM cell.

Thermische Schmierkeilbildung. Lütfüllah Ulukan. *Istanbul Tek. U., Bul.*, 1956, pp. 77–102. In German. Investigation of the thermal influence of oil wedge formation on the load capacity of parallel oil films, which can be calculated in terms of linear temperature distribution for infinitely thick lubricating film of varying viscosity.

The Use of Polytetrafluoroethylene as a Lubricant. E. Kay and E. D. Tingle. *Gt. Brit., RAE Rep. Chem.505*, Apr., 1956. 41 pp. 30 refs.

Liquid Hydrogen as a Rocket Propellant. Alexis Pastuhov and C. Lincoln Jewett. *Aero Dig.*, Sept., 1956, pp. 35–39. Discussion of the potentialities of hydrogen as a rocket fuel, and of a helium refrigeration system used for liquefaction and storage.

Properties of Fuming Nitric Acid Affecting Its Storage and Use as a Rocket Propellant. David M. Mason. *Jet Propulsion*, Sept., 1956, pp. 741–744, 756. 29 refs.

The Design of Cylindrical Propellant Grains. L. Ivan Epstein. *Jet Propulsion*, Sept., 1956, pp. 757–759. Discussion of mathematics of the design of a cylindrical propellant grain and of an internally burning propellant grain. Includes description of a method for designing a grain in which the burning surface area is a prescribed function of the portion of the web thickness burned through.

The Relative Reactivities of Bifunctional Monomers. IV—The Preparation of Some Olefinic Alcohols and Their Methacrylate Esters. G. M. Bristow. *Gt. Brit., RAE TN Chem.1278*, May, 1956. 9 pp. 13 refs.

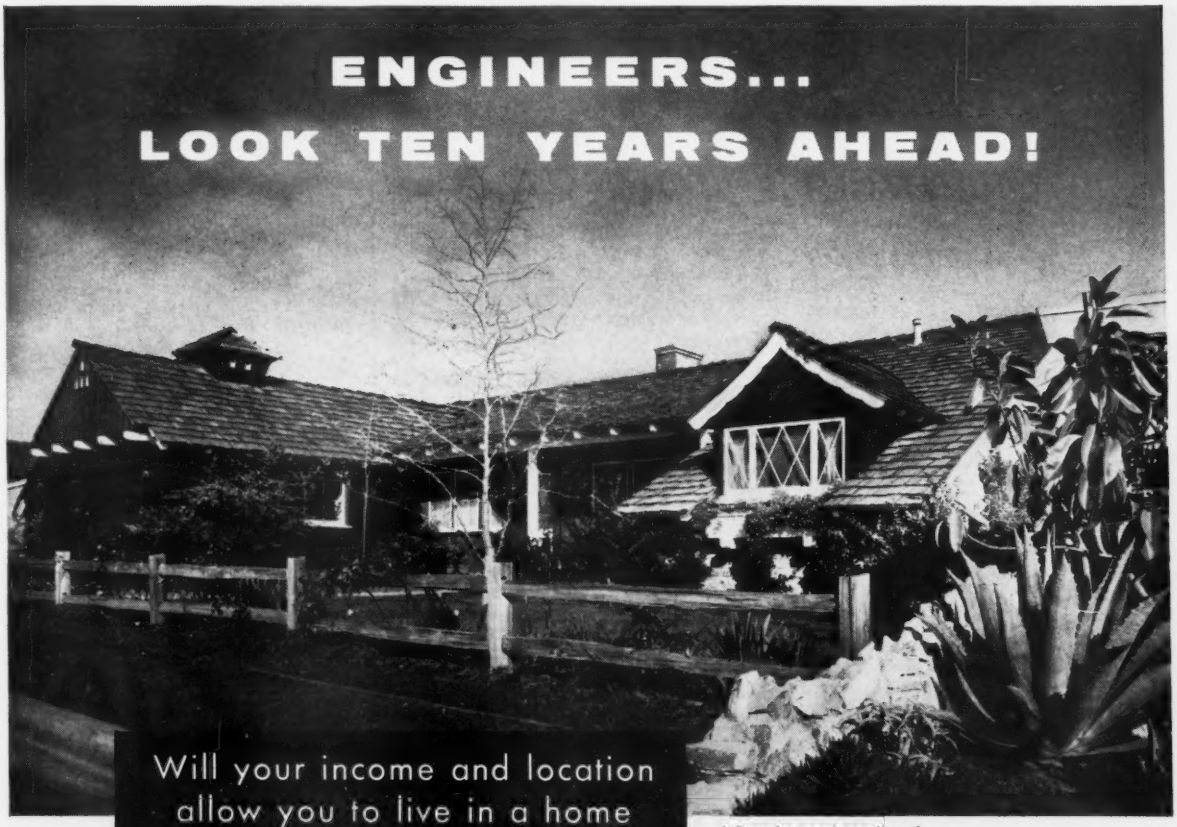
Ice Formation & Prevention

Report of the Second Year's Flying on the Development of Flight Testing Techniques for Finding and Measuring Natural Icing Conditions. G. C. Abel. *Gt. Brit., ARC CP 222* (Mar. 3, 1954), 1956. 39 pp. BIS, New York, $0.72.

Instruments

Flight-Table Instrumentation. Robert H. Esling. *Instruments & Automation*, Sept., 1956, pp. 1,789–1,791. Discussion of a three-dimensional flight table which simulates torques, angular accelerations, and angular velocities experienced in flight. The flight table consists of a high-performance, servocontrolled gimbals sys-

ENGINEERS...
LOOK TEN YEARS AHEAD!



Will your income and location allow you to live in a home like this...spend your leisure time like this?

A Douglas engineer lives here

They can...if you start your Douglas career now!

Douglas has many things to offer the career-minded engineer!

...there's the stimulating daily contacts with men who have designed and built some of the world's finest aircraft and missiles!

...there's enough scope to the Douglas operation so a man can select the kind of work he likes best!

...there's security in the company's $2 Billion backlog of military and commercial contracts!

...and there's every prospect that in 10 years you'll be where you want to be professionally, and you'll be in both the income level and geographical location to enjoy life to its full.

For further information about opportunities with Douglas in Santa Monica, El Segundo and Long Beach, California and Tulsa, Oklahoma, write today to:

DOUGLAS AIRCRAFT COMPANY, INC.
C. C. LaVene, 3000 Ocean Park Blvd.
Santa Monica, California

DOUGLAS **First in Aviation**

A message to engineers from an engineer-president

Marquardt was incorporated in 1944 by five engineers and three Los Angeles businessmen to explore the potential of the ramjet engine – then merely a laboratory curiosity.

Twelve years of sound engineering and research have really paid off. Today we employ over 2000 people at Los Angeles and Ogden, Utah and expect to triple in the next two years. Of course, many of our new associates will be in manufacturing –which is fine. Every engineer wants to see his "baby" accepted and in production. However, the outstanding work of our present engineering and research team has also opened up big new requirements for engineers in almost every specialty in areas varying from production engineering and qualification testing of present models to advanced research on startling new break-throughs in high speed propulsion – new chemical fuels and nuclear energy.

It is not too late to get in on the ground floor on engineering the ramjet engine – the powerplant of the future. Write me personally now.

Roy E Marquardt

Marquardt Aircraft Co.
Van Nuys, California

tem which follows command inputs from an analog computer.

Linear Mechanism Controls Feed to Microinches. *Tool Engr.*, Oct., 1956, p. 90. Description of an Airborne Instruments Laboratory unit which can be applied to respond directly to gage signals through a simple converter.

The Effect of Spring Mass on Contact-Accelerometer Responses. T. H. Lin. (*ASME Natl. Appl. Mech. Conf., Urbana, June 14–16, 1956.*) *J. Appl. Mech.*, Sept., 1956, pp. 385–389. 12 refs. Analysis of theoretical responses of a contact-break accelerometer for steady-state and some transient motions, taking into account the distributed mass of the spring and assuming viscous damping between the spring and the instrument case for steady-state motions. Includes illustration of responses to simple harmonic motions of different frequencies, investigation of responses to a single cosine wave and a step function of acceleration, and preliminary study of a proposed electromagnetic-contact accelerometer with no spring mass.

Integrated Control Systems for Aircraft. R. Hadekel. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 2–6, 1956, Preprint 838.* 6 pp. Analysis of a theoretical control system combining power actuation, artificial stabilization, and automatic flight control. The system would consist of sensing instruments capable of detecting any departure of the aircraft from the desired path and the desired state of uniform oscillation-free motion. This information is fed to a control device, a computer, which determines movements required for correction and sends suitable signals to the actuators which operate the control system.

The Synthesis of Aircraft Hydraulic Servos. George R. Keller and Elliott R. Buxton. *SAE Natl. Aero. Meeting, Los Angeles Oct. 2–6, 1956, Preprint 839.* 11 pp. Discussion of the developmental procedure necessary for the design of servo-systems, which includes means of determining and specifying dynamic requirements, integration of hydraulic and electronic elements, actuator and control valve design, and methods for servo testing.

A New Aircraft Instrument; Sperry Announce the H.L. 9 D.C.-A.C. Gyro Horizon. *Sperry Rev.*, Summer, 1956, p. 4. Description of an instrument of standard $3^1/_4$-in. size, which is capable of operating from either an a.c. or d.c. power supply, indicates pitch information at standard sensitivity over a total range of movement of plus or minus 10° on either side of the datum and beyond that range by an auxiliary drum dial, and eliminates the need for shock-proof mounting.

On a New Dial Presentation System of Gyro Horizon. Shin'ichiro Takeda. *J. Japan Soc. Aero. Eng.*, Aug., 1956, pp. 6–10. Description of a dial presentation system of the gyro horizon which indicates the attitude of the airplane by showing the attitude of a miniature model airplane relative to the artificial horizon line fixed to the case of the gyro horizon.

Servo-Operated Recording Instruments. A. J. Maddock. *Proc. IEE, Part B*, Sept., 1956, pp. 617–632. 37 refs. Historical review of several available types of servo-

operated recording instruments and detailed discussion of the principal types of modern instruments, classified according to the circuit component which is varied to produce balance—resistance or potentiometer, capacitor, or electromagnetic device.

Methods of Manufacture of Wire Resistance Strain Gauges. I. G. Scott. *Australia, ARL S&M Note 226*, May, 1956. 20 pp. Survey of various methods used for the manufacture of strain gages in Australia and England.

Automatic Temperature Controls. Raymond H. Matthews. *Prod. Eng.*, Sept., 1956, pp. 179–183. Description of the operation and characteristics and comparison of service temperature ranges of expanding-metal, expanding-fluid, and electronic temperature-sensing elements and controls. Typical applications are included.

Industrial Thermistor Applications. Robert S. Goodyear. *Elec. Mfg.*, Oct., 1956, pp. 90–96. Discussion of the three basic characteristics for the use of temperature-sensitive semiconductors as components in the design of controls and instrumentation, their current use, and some suggested applications.

Vibration Instrumentation. I. *CEC Recordings*, Sept.-Oct., 1956, pp. 8, 9. Brief description of the theory and properties of various types of measuring instruments.

Capteurs de Vibrations et Excitateurs Harmoniques à Fréquence Propre Variable. R. Destuynder and H. Loiseau. *La Recherche Aéronautique*, July-Aug., 1956, pp. 53–55. In French. Description of vibration exciting and recording devices used for studying experimentally the vibration characteristics of slightly damped structures. These devices are used for obtaining resonance curves, for analyzing damping performance, and for calculating the deformations of harmonically excited structures.

Investigations on and Improvements to a Vibration Galvanometer. G. Von Mayrhauser. (*ZAP*, No. 2, 1948, pp. 68–75.) *Gt. Brit., RAE Lib. Transl. 585*, July, 1956. 17 pp. Description of two systems developed to improve the sensitivity and range of a frequency-independent vibration galvanometer. With the two systems described, a range of 15 cps to 850 cps can be covered.

Laws & Regulations

Jurisdictional Control of Airflight. John A. Eubank. *Pittsburgh U. Law Rev.*, Summer, 1956, Reprint. 8 pp.

Machine Elements

Analytical Methods for Designing Dynamic Vibration Absorbers. Harry Himelblau, Jr. *Mach. Des.*, Sept. 20, 1956, pp. 134–140. Method for absorbing vibration of constant-speed machinery with an auxiliary spring-mass system.

Why Bearings Fail. D. F. Wilcock and E. R. Booser. *Prod. Eng.*, Oct., 1956, pp. 167–182. 12 refs. Systematic description of the most common causes and remedies for sliding- and rolling-bearing failure, with an outline of a trouble-shooting procedure and a check chart listing symptoms, cause, and cure.

How to Choose Antifriction Bearing Materials. John Preston, Jerome Mogul, and George Floroff. *SAE J.*, Sept., 1956, pp. 56–59. Discussion of six criteria: cleanliness, hardness, tempering temperature, dimensional stability, workability, and compatibility with existing lubricants.

Surface Film Formation and Metallic Wear. W. Hirst and J. K. Lancaster. *J. Appl. Phys.*, Sept., 1956, pp. 1,057–1,065. 12 refs. Experimental investigation to determine wear factors from friction studies. It is shown that when a relatively soft metal slides on a harder one, the relationships between the wear and the sliding distance may be one of three general types, each associated with the formation of a surface film.

Unique Graphical Study Demonstrates Fundamentals of Face-Gear Geometry. Louis D. Martin. *Mach. Des.*, Oct. 4, 1956, pp. 106–112. Discussion of the advantages and limitations of face gears, and methods for determining tooth profiles.

A Survey of Intermittent-Motion Mechanisms. F. J. Bogardus. *Mach. Des.*, Sept., 20, 1956, pp. 124–131. 20 refs. Classification of intermittent-motion mechanisms into eight groups according to their input and output motions.

Wear Life of Aluminum Gears. A. H. Maschmeyer. *Prod. Eng.*, Sept., 1956, pp. 160–166. Theoretical investigation to develop a method for estimating probable life span, to modify Hertz's equations so that they conform to experimental results, and to compare anodized and unanodized gears.

Ausschlag eines Rotors beim Durchgang durch die kritische Drehzahl. W. Traupel and P. Suter. *ETH Inst. für Thermische Turbomaschinen, Mitteil. No. 3*, 1956, pp. 39–60. In German. Analysis of the influence of damping on a rotor passing the critical number of revolutions.

Seals for Aircraft Gas Turbine. *SAE J.*, Sept., 1956, pp. 46–53. Outline of problems associated with mainshaft bearing lubrication systems, containing or controlling airflow within proper channels and preventing excessive loss of the working fluid, and with sealing of accessory drives.

Designing Springs for Performance. Walter E. Froehlich. *Prod. Eng.*, Sept., 1956, pp. 135–139. Discussion of the three basic considerations for sound design (economy, compactness, and long life), the increased complexity of spring requirements, and new materials and advances in fabricating techniques. Includes specific recommendations for drawing purposes.

Maintenance

Aircraft Maintenance Docks. D. W. Setterington and P. J. Adams. *J. SLAE*, Aug., 1956, pp. 2–5; Discussion, pp. 5–10. Design of fixed docks engineered to save man-hours; provide safe access and good working conditions; reduce aircraft damage, equipment maintenance, and interference between operators and shorter pipe runs; eliminate time spent in finding or moving staging; save hangar space; and improve inspection and workmanship.

The B.O.A.C. Dock for Britannia Aircraft. A. J. Ferguson. *J. SLAE*, Aug., 1956, pp. 11–17. Description of the general layout, main ground-supported, overhead, fin-and-rudder-maintenance, and power-unit-maintenance structures, and of the control point, aircraft entry, and maintenance organization.

Materials

Special Issue: Ninth Annual Unit Processes Review; Tenth Annual Materials of Construction Review. *Ind. & Eng. Chem.*, Sept., 1956, Pt. 2. 255 pp. 5,415 refs. Partial Contents: Aluminum Alloys, R. L. Horst. Ceramics, Lane Mitchell. Elastomers, Harry L. Fisher. Fibers, C. S. Grove, Jr., Robert S. Casey, and Joseph L. Vodonik. Plastics, Raymond B. Seymour. Titanium, H. B. Bomberger.

The Choice of Materials for Airframes. K. L. C. Legg. *Aircraft Eng.*, Sept., 1956, pp. 304–312. Review and evaluation of existing materials and those likely to be available in the future, in terms of the technological and production problems to be encountered in advance aircraft design.

Arc Melting Molybdenum. George A. Timmons and Robert G. Yingling. *Technology of Molybdenum and Molybdenum-Base Alloys, Symposium, Detroit, Sept. 18, 19, 1956, Paper.* 32 pp. Description of the pressing-sintering-melting machine, its basic charge and product, with a historical review and discussion of other types of melting equipment.

Metals & Alloys

A Dictionary of Metallurgy. XLVII—*Ta–Th*. A. D. Merriman and J. S. Bowden. *Metal Treatment*, Sept., 1956, pp. 367–374.

The Fabrication of Molybdenum. J. D. Nisbet and W. L. Bruckart. *Technology of Molybdenum and Molybdenum-Base Alloys, Symposium, Detroit, Sept. 18, 19, 1956, Paper.* 10 pp.

Properties & Applications of Commercial Molybdenum & Molybdenum Alloys. Robert R. Freeman. *Technology of Molybdenum and Molybdenum-Base Alloys, Symposium, Detroit, Sept. 18, 19, 1956, Paper.* 21 pp.

Forging of Molybdenum Alloy Turbine Buckets. J. J. Russ and G. E. Schrader. *Technology of Molybdenum and Molybdenum-Base Alloys, Symposium, Detroit, Sept. 18, 19, 1956, Paper.* 14 pp. Evaluation of two forging methods in order to determine the feasibility of precision forging of turbine blades. The two approaches include the resistance upset and forged method and the rolled and forged method.

The Protection of Molybdenum Against High-Temperature Oxidation (A Survey of the Problem and Progress). Julius J. Harwood. *Technology of Molybdenum and Molybdenum-Base Alloys, Symposium, Detroit, Sept. 18, 19, 1956, Paper.* 39 pp. 21 refs.

The Potential and Future of Molybdenum and its Alloys. Alvin J. Herzig. *Technology of Molybdenum-Base Alloys,*

Symposium, Detroit, Sept. 18, 19, 1956, Paper. 10 pp.

Super-High Strength Steels for Aircraft Applications. J. W. Sands. (*Sagamore Res. Conf., Aug., 1955, Proc., Reprint.*) *Internatl. Nickel Co.*, 1955, Paper. 31 pp. Discussion of developments with tables and charts depicting the physical, mechanical, and chemical properties of steels up to and beyond the strength of 300,000 psi.

Notes on the Brittle Fracture of Steels. *The Engr.*, Sept. 28, 1956, pp. 443–447. Investigation into the mechanism of fracture in the high and low ranges of notch impact values.

High Temperature Materials—A Review. Eric A. Brandes. *Prod. Eng.*, Sept., 1956, pp. 186–190. Discussion covering the early development, required properties, methods of evaluation, available materials, and future materials and techniques.

Metals at Elevated Temperatures. R. W. Guard. *Prod. Eng.*, Oct., 1956, pp. 160–164. Comparison of hot and cold behavior of metals by a homologous temperature scale, and of the relative values of fatigue and rupture stress as design criteria for predicting long-term properties from short-term tests.

Metallische Werkstoffe. E. Siebel. *VDI Zeitschrift*, Sept. 21, 1956, pp. 1,617–1,621. 91 refs. In German. Extensive bibliography on temperature resistant materials.

Development of Nickel-Chromium Base Alloys for High-Temperature Service. I—Composition and Heat Treatment. W. Betteridge and A. W. Franklin. *Metal Treatment*, Sept., 1956, pp. 343–348. Discussion of complex alloys strengthened by precipitation hardening with a nickel-aluminum-titanium compound, or by additions of other metals such as cobalt to the solid solutions. Characteristics of the alloys are described for temperatures between 750° and 1,000°C.

Metals & Alloys, Nonferrous

Aluminum and Magnesium Extrusions. J. J. DePaolo. *Prod. Eng.*, Oct., 1956, pp. 200–203. Evaluation of extrusions classified by shape, with a tabulation of the most commonly used alloys, and evaluation of various shapes in terms of tolerances and costs.

A Study of the Constitution of Some Titanium-Oxygen-Vanadium Alloys. D. A. Sutcliffe. *Gt. Brit., RAE TN Met.233*, Mar., 1956. 19 pp. 10 refs.

Tensile Properties of Inconel and RS-120 Titanium-Alloy Sheet Under Rapid-Heating and Constant-Temperature Conditions. George J. Heimerl, Ivo M. Kurg, and John E. Inge. *U.S., NACA TN 3731*, July, 1956. 29 pp. Experimental investigation including a comparison of yield and rupture stresses, obtained by rapid heating, with yield and ultimate stresses from elevated-temperature tensile stress-strain tests, for 1/2-hour exposure. Also includes a determination of the applicability of master curves and temperature-rate parameters to the prediction of yield and rupture stresses and temperatures under rapid-heating conditions.

The Changes in Hardness During Fatigue Tests on Copper at 6000 Cycles/Minute. R. B. Davies and J. Y. Mann. *Australia, ARL Rep. Met.16*, May, 1956. 16 pp.

Sur la Désorganisation et la Restauration à Froid de Cristaux d'Aluminium Soumis à des Tractions Faibles. J. Caisso. *France, Min. de l'Air PST 316*, 1956. 46 pp. 25 refs. SDIT, 2 Av. Porte-d'Issy, Paris 15, Frs. 950. In French. Experimental investigation of perturbations due to traction in aluminum monocrystals, using the Guinier and Tennevin method.

Growing Importance of Magnesium. *Metal Treatment*, Sept., 1956, pp. 353, 354. Discussion of hammer-forming, machining, and handling properties of magnesium.

The Drawing of Titanium. James S. Kirkpatrick. *Steel Processing*, Sept., 1956 pp. 523–528. Discussion of the industrial development, mechanical properties, advantages, and applications of titanium.

Stress Corrosion in Titanium and Its Alloys. Mars G. Fontana. *Ind. & Eng. Chem.*, Sept., 1956, Pt. I, pp. 59-A, 60-A. Investigation of stress corrosion which shows that the metal has good resistance to this type of corrosion in spite of unfavorable heat-treatment conditions.

Reclamation of Titanium Alloys by Vacuum Annealing. D. N. Williams, R. I. Jaffee, and C. A. Bentley, Jr. (*Metal Prog.*, June, 1956, pp. 57–59.) *Engr. Dig.*, Sept., 1956, pp. 384, 385.

Nonmetallic Materials

Service Temperature Characteristics of Molded Acrylic Parts. J. J. Gouza and E. N. Robertson. *SPE J.*, Sept., 1956, pp. 19–24.

Thermal Degradation of Various Polymers over the Range 300°–600°C. D. Sheehan. *Gt. Brit., RAE TN Chem.1280*, May, 1956. 19 pp. Tests to obtain residues of high carbon content by heating certain polymers in air and in nitrogen. Investigation includes study of other materials, including chlorinated linear polymers, melamine-formaldehyde resins, polybenzyl and its naphthalene analog, and polyphenylenes prepared by Wurtz syntheses from di- and trichlorobenzenes. These syntheses are described in full.

Wirtschaftlichkeit und Möglichkeiten der Anwendung glasfaserverstärkter Kunststoffe. Fritz Brockmöller. *VDI Zeitschrift*, Sept. 21, 1956, pp. 1,603–1,610. 21 refs. In German. Evaluation of glass-fiber reinforced plastics and their application.

Sur la Fractographie Macroscopique des Résines Polyester. A. Popoff. *La Recherche Aéronautique*, July-Aug., 1956. pp. 41, 42. In French. Analysis of the stress-strain resistance of polyester resins.

How Rubbers Stand Up at High Temperatures. G. M. Konkle, J. T. McIntyre, and J. V. Fenner. *Av. Age*, Sept., 1956, pp. 70, 71, 72–75 ff. Investigation at temperatures up to 250°C. of the tensile strength and elongation of ten elastomer types.

Testing

Impact Torsion Experiments. N. G. Calvert. *IME Proc.*, No. 44, 1955, pp. 897–902. 12 refs. Investigation made at low speeds (4 rad per sec. or less) to explore the region between static and impact conditions. Results from mild steel tests show that both upper and lower yield points increase progressively with the rate of straining.

Experiments on the Effect of Rate of Testing on the Criterion of Failure of Certain Mild Steels when Subject to Dynamic Torsion and Static Tensile Stresses. N. G. Calvert. *IME Proc.*, No. 44, 1955, pp. 903–907; Discussion, pp. 907–909.

Mathematics

Fundamentals of Analysis of Variance. II—The Components of Variance Model and the Mixed Model. Charles R. Hicks. *Ind. Quality Control.*, Sept., 1956, pp. 5–8.

On Singular and Regular Cauchy Problems. J. B. Diaz. *U. Md. Inst. Fluid Dynamics & Appl. Math. TN BN-79 (AFOSR TN 56-354)*, July, 1956. 14 pp. 14 refs.

The Determination of Eigenfunctions of the Sturm-Liouville Equation; Expansion in Trigonometric Series. S. C. R. Dennis. *Quart. J. Mech. & Appl. Math.*, Sept., 1956, pp. 371–383. 10 refs. Description of a general numerical method of approach in which the eigenfunctions are expressed as an infinite series of trigonometrical functions, orthogonal over a finite interval of integration, and in which the Sturm-Liouville equation is reduced to an infinite set of linear simultaneous algebraic equations (containing the characteristic parameter and solvable by standard iterative or relaxation methods) for the coefficients of the series.

A Rapidly Converging Solution of the Conformal Mapping Problem of Hydrodynamics. Leonard Pode. *U.S., Navy Dept., David W. Taylor Model Basin, Rep. 1041*, July, 1956. 17 pp. Method of computing the conformal transformation for mapping the region exterior to a simple closed boundary curve onto the region exterior to a circle.

Determining Fourier Series Coefficients Graphically. W. H. Middendorf. *Elec. Eng.*, Oct., 1956, p. 913. Abridged. Analysis of a saw-tooth wave to develop a new method involving the alteration in the number of segments to a multiple of the harmonic number as each coefficient is computed. Applicable for determining the coefficients of the higher harmonics.

Summation of a Slowly Convergent Fourier Series Occurring in a Fluid Motion Problem. G. F. Miller. *Proc. Royal Soc. (London), Ser. A*, Sept. 25, 1956, pp. 17–27. Description of methods for the evaluation of a slowly convergent sine series $s(\theta)$ $[0 \leq \theta \leq (1/2)\pi]$, in which the coefficients satisfy a linear recurrence relation; establishment of a connection between $s(\theta)$ and the hypergeometric function; and derivation of a general technique for evaluating an extensive class of power series in a complex variable.

Die Anzahl der Nullstellen eines Polynoms in Gebieten mit stückweise rationalen Randkurven. Wilhelm Klingenberg. *ZAMP*, July 25, 1956, pp. 304–316. In German. Calculation of the number N of zeros of a polynomial $w(z)$ in certain regions of the complex plane. A solution is given for the case in which the region is simply connected, and its boundary is composed of a finite number of pieces of rational curves.

This modern, air-conditioned building is now being erected to house the Columbus Engineering Department.

Engineers! Move into this completely modern building with us

Continued expansion of the Engineering Department at North American's Columbus Division makes necessary the addition of this air-conditioned building—modern in design, with finest facilities, including the latest IBM 704 and extensive analog computing equipment.

The Department has sixteen fully equipped laboratories for the use of creative engineers, to cope with its increasing responsibilities. These include all design, development, production, flight test and field service on North American aircraft for the Navy, now in operation or under development.

As an engineer, you will appreciate what these developments mean in terms of career opportunities for YOU. Good men are assured of recognition here. North American's Columbus Division is a major airframe builder, covering every phase of aircraft engineering from concept to flight; and it is also a vigorous, completely integrated organization where growth prospects are excellent.

If you have experience, creative ability and the willingness to make the most of your own professional capacities, you owe it to yourself to find out about a career with North American in Columbus.

OPPORTUNITIES IN EVERY FIELD:

Aerodynamicists, Thermodynamicists, Dynamicists, Stress Engineers, Structural Test Engineers, Flight Test Engineers, Mechanical and Structural Designers, Electrical and Electronic Engineers, Wind Tunnel Model Designers and Builders, Power Plant Engineers, Research and Development Engineers, Weight Engineers.

There will never be a better time—write NOW: Mr. J. H. Papin, Personnel Manager, Dept.56-12AER, North American's Columbus Division, Columbus 16, Ohio.

THE COLUMBUS DIVISION OF

NORTH AMERICAN AVIATION, INC.

Products of Basic Sets of Analytic Functions. W. F. Newns. *Proc. Royal Soc. (London), Ser. A*, Sept. 25, 1956, pp. 55–62. Proof of theorems on the effectiveness of the product of two basic sets, showing that in certain cases the effectiveness of the factors is necessary for that of the product.

A Note on the Numerical Solution of Certain Non-Linear Integral Equations. G. F. Miller. *Proc. Royal Soc. (London), Ser. A.*, Sept. 11, 1956, pp. 529–534. Description of methods for solving two equations occurring in a hydrodynamic problem, and derivation of the asymptotic form of the solutions for lage x.

Die Summierung divergenter Reihen durch analytische Fortsetzung mittels der Theorie der Differenzengleichungen. Cevdet Koçak. *Istanbul Tek. U., Bul.*, 1956, pp. 43–57. In German. Development of a method for the summation of divergent series by an analytic extension using the theory of difference equations.

Vertex Parts at Very High Energies in Quantum Electrodynamics. V. V. Sudakov. (*Zhurnal Experimental'noi i Teoreticheskoi Fisiki*, Jan., 1956, pp. 87–95.) *Soviet Physics—JETP*, Aug., 1956, pp. 65–71. Translation. Development of a method for calculating Feynman integrals with logarithmic accuracy, working to any order of perturbation theory, and application of the method to calculate the vertex part in quantum electrodynamics over a range of values of momenta. Result is displayed as the sum of a perturbation series.

Some Ergodic Theorems for One-Parameter Semigroups of Operators. D. G. Kendall and G. E. H. Reuter. *Philos. Trans. Royal Soc. (London), Ser. A*, Sept. 20, 1956, pp. 151–177. 13 refs.

On the Functions of the Parabolic Cylinder. David I. Epstein. *NYU Inst. Math. Sci., Div. Electromagn. Res., Res. Rep. BR-19*, June, 1956. 24 pp. OSR-sponsored derivation of an additional theorem in parabolic coordinates for the separated solutions of the reduced wave equations, based on the property that the reduced wave equation is invariant under translations and rotations of the coordinate system.

Opérateurs Symboliques. Henri Pailloux. *France, Min. de l'Air PST 317*, 1956. 77 pp. SDIT, 2 Av. Porte-d'Issy, Paris 15, Frs. 880. In French. Modification of the definition of symbolic linear operators to include functions of one or more variables.

Extreme Value Properties of Hermitian Matrices. M. Marcus and B. N. Moyls. *U. Brit. Columbia, Dept. Math., AFOSR TN 56-341*, Aug., 1956. 36 pp. 21 refs.

Einige unstetige stochastische Prozesse. Andreas Dalcher. *ZAMP*, July 25, 1956, pp. 273–304. 10 refs. In German. Analysis of stochastic processes where at random time points (t) the variable $x(t)$ jumps from y to x. The heights x-y have a given distribution that may depend on y or t.

Meteorology

The Question of the Formation of a Cellular Structure in a Layer of Fog or Smoke. V. K. Liapidevskii. (*Zhurnal Experimental'noi i Teoreticheskoi Fisiki*, Feb., 1956, pp. 309–400.) *Soviet Physics—JETP*, Sept., 1956, pp. 287–290. Translation. Includes observations of the homogeneous wake produced by an aircraft in the upper layer of the atmosphere.

A New Upper Air Data System—The Transosonde. Albert D. Anderson and Henry J. Mastenbrook. *Bul. AMS*, Sept., 1956, pp. 342–350. 12 refs. Description of a method involving the use of instrumented balloons controlled to float along given constant-pressure surfaces in the atmosphere in order to derive meteorological data on wind velocities and accelerations.

An Unusual Refraction Phenomenon Seen from a High-Flying Aircraft. C. S. Durst and G. A. Bull. *Meteorological Mag.*, Aug., 1956, pp. 237–242. Discussion of unusual cloud effect observed in an aircraft flying at 45,000 ft. A mushroom-type cloud was observed well above the regular cloud formation. This phenomenon was explained as being caused by rays reflected at three points from the curved surfaces of a cloud inversion.

Weather Forecasting from Solar Radiation. E. A. Smith. *Aeronautics*, Oct., 1956, p. 75. Discussion of experiments, the results of which indicate that the study of solar radiation may lead to the development of reliable methods of long-term weather forecasting.

Military Aviation & Armament

Air Force in the International Geophysical Year. Milton Greenberg and Alan M. Gerlach. *Air U. Quart. Rev.*, Spring, 1956, pp. 70–84.

Selection of an Advanced Weapon System. George W. Jeffs. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 2–6, 1956, Preprint 831.* 12 pp. Review of the selection procedures from the establishment of the military requirements to the final design definition. Discussion includes an outline of design-analysis techniques, used in optimizing the air-vehicle portion of the weapon system, and stresses the importance of integrating similar design analyses conducted on all major elements of the system to produce a weapon system of maximum military effectiveness.

The Role of Ground Operations in a Weapon System. Wallace E. Reese. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 2–6, 1956, Preprint 841.* 8 pp. Description of the Ground Operations Plan, the coordination of development, handling, shipping, and use of weapons, enrollment and employment of manpower, selection of ground-support equipment, maintenance, and choice and location of operational facilities.

The Influence of a Ground Support System on Combat Mobility. L. R. Hackney. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 2–6, 1956, Preprint 840.* 13 pp. Description of the Air-Log system and its subsidiaries.

The Inevitable Interceptor. John W. R. Taylor. *Saro Prog.*, Autumn, 1956, pp. 7–9. Discussion citing needs and the advantage of a mixed-power-unit fighter combining jet and rocket power.

Operational Aspects of the SAC Transition to Jets. Richard E. Evans. (*IAS Natl. Summer Meeting, Los Angeles, June 18–21, 1956, Preprint 641.*) *Aero. Eng. Rev.*, Nov., 1956, pp. 86–94.

Navigation

Technological Barriers to Progress in the Field of Navigational Instrumentation. Helmut Schlitt. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 2–6, 1956, Preprint 835.* 7 pp.

Three-in-One Navaid Package for Supersonic Flight. James Holahan. *Av. Age*, Sept., 1956, pp. 96, 97, 98–101 ff. Development of a civil navigation aids system in which three receivers are combined into a single 40-lb. package.

Nuclear Energy

A Note on the Effect of the Residual Gas Pressure Upon the Spacing of Mass Spectroscopic Doublets. Neil R. Isenor, G. Ronald Bainbridge, Philip C. Eastman, and Henry E. Duckworth. *Can. J. Phys.*, Sept., 1956, pp. 993–995. OSR-supported research.

Neutron Flux Spectra in Air. Samuel S. Holland, Jr., and Paul I. Richards. *J. Appl. Phys.*, Sept., 1956, pp. 1,042–1,050. 26 refs. USAF-supported research applying Spencer's and Fano's moment method to the penetration and slowing down of neutrons in infinite media.

Parachutes

Parachutes. W. D. Brown. *Aeronautics*, Sept., 1956, p. 73. Brief discussion of progress in the design and use of parachutes.

Photography

Die Photographie in der Technik. W. Rickers. *VDI Zeitschrift*, Sept. 21, 1956, pp. 1,597–1,601. In German. Discussion of technical applications of photography, including schlieren and flow-visualization research.

Physics

Enclosed Quantum Mechanical Systems. T. E. Hull and R. S. Julius. *Can. J. Phys.*, Sept., 1956, pp. 914–919. 12 refs. ARDC-supported research, including the description of a method which leads to a general asymptotic formula for the eigenvalue problems associated with enclosed quantum mechanical systems.

The Permutation Group and Electron Quantum Mechanics. F. A. Matsen. *U. Wis. NRL Dept. Chem. TR WIS-OOR-14*, Aug. 28, 1956. 30 pp. General description of polyelectronic systems using the theory of the permutation group.

First Correction to the Geometric-Optics Scattering Cross Section from Cylinders and Spheres. S. I. Rubinow and T. T. Wu. *J. Appl. Phys.*, Sept., 1956, pp. 1,032–1,039. 17 refs. USAF-ORR-supported analysis of the total scattering cross section in the short wavelength limit. Problems treated include diffraction of a plane electromagnetic wave by a conducting cylinder or a conducting sphere, acoustic scattering by a rigid sphere, and

A great step forward in the automation of fuel systems

1,200 hour "Dry Run" torture test Proves Reliability of HY-V/L* Fuel Pumps

On September 1, 1956, a HY-V/L fuel pump (Model 60-029) completed 1,265 hours of continuous operation under simulated jet fighter conditions. The test was run in three-hour cycles: one hour "wet run" (submerged in fuel) at sea level, followed by two hours "dry run" (without fuel) at 50,000 feet with 150° F. ambient temperature.

In an earlier test, the HY-V/L pump (Model 60-071) ran "dry" continuously for 18 hours at an altitude of 55,000 feet, simulating conditions encountered in a long-range jet bomber.

In both tests the case temperature of the HY-V/L pump stayed well below the dangerous auto-ignition mark (400° F). The HY-V/L pump requires no thermal protection, even under a locked rotor condition.

Every Fighter, Every Bomber, Every Transport is Hydro-Aire Equipped

These test results are steps forward in the complete automation of fuel systems. Because the HY-V/L pump requires no thermal protection device, it offers much greater reliability; because it runs "dry" safely, it needs no switch or other shutoff device.

Remember the advantages of the HY-V/L pump: simple . . . compact . . . lighter . . . eliminates the old vapor separator . . . uses less power . . . excellent climb performance . . . recovers immediately . . . pumps all types of avgas and jet fuels . . . has "Design Predictability," i.e. it can easily be tailored to your specific needs. Write for complete details.

**High Vapor/Liquid Ratio*

HYDRO-AIRE Inc.

3000 WINONA AVE., BURBANK, CALIF.

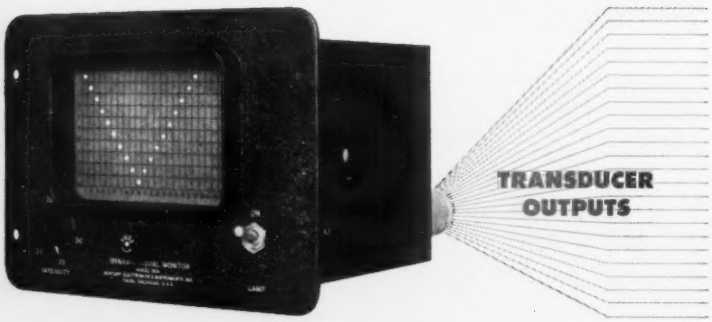
the aviation subsidiary of CRANE

also make

Fuel Gate Valves, Hot Air Valves, and the "Hytrol" Anti-Skid Braking System.

Your
electronic
Problems
receive IMMEDIATE and SPECIAL ATTENTION
in DEVELOPMENT and PRODUCTION of
GUIDED MISSILE Components:
FUEL CUT-OFF RECEIVERS, TELEMETERING
TRANSMITTERS, POWER SUPPLIES FOR BEACONS.
RADAR TEST SETS
SPECTRUM ANALYZERS
SIGNAL GENERATORS
FREQUENCY COUNTERS
And other devices now in production for Army, Navy and Air Forces on prime and sub contracts.
MANCHESTER NEW HAMPSHIRE
NORTHEASTERN ENGINEERING INC.

Century **MODEL 20 VISUAL MONITOR**



For **TEMPERATURE PRESSURE VIBRATION FLOW RADIATION COLORIMETRY CURRENT VOLTAGE**

Does your data problem include any of the above? Or anything similar?

The Model 20 Visual Monitor is a completely new concept in multiple data-point indication.

Now you can observe and measure 24 separate data points, simultaneously. No Switching, no commutating, no time lag.

Wherever a graphic display of several quantities will facilitate measurement and control, the Model 20 should be considered.

Utilizing light-beam D'Arsonval galvanometers as the indicating elements, the Visual Monitor permits display of transducer output in an easy-to-interpret, graphic form.

Let us hear from you. We would like to discuss your instrumentation problems with you.

Century Electronics & Instruments, Inc.
1333 No. Utica, Tulsa, Oklahoma

quantum-mechanical scattering by an impenetrable sphere.

Power Plants

The Place of British Power Plants in the World's Aviation. James Hay Stevens. *Aeronautics*, Sept., 1956, pp. 88–95. Includes charts of performance characteristics of various types of power plant.

Induction System Selection. Appendix —Analytical Comparison of Isentropic Internal and External Compression Inlets. Harry Drell and Thomas A. Sedgwick. *Aero. Eng. Rev.*, Nov., 1956, pp. 67–75. Examination of various types of induction system, with results leading to suggestions for selecting the optimum design.

Jet & Turbine

The Birth and Evolution of the Gas Turbine. V. E. Crompton. *Can. Aero. J.*, Sept., 1956, pp. 259–263. Review of Whittle's work in the development of the first jet engine. Includes a chronological survey of early British, American, and German research in the field.

Turbine Disks for Jet Propulsion Units; An Account of Work of the Disk Panel of the Ministry of Supply, Gas Turbine Collaboration Committee, During the Years 1941-1942. A. E. Johnson. *Aircraft Eng.*, Sept., 1956, pp. 325–332.

La Combustion Dans les Réacteurs d'Aviation. Th. Seifferlein. *Assoc. Tech. Marit. & Aéro., Paris, Session 1956.* 19 pp. 21 refs. In French. Evaluation of fundamental aerodynamic and thermodynamic concepts, with an analysis of their application, based on investigations of three systems, including combustion chambers in turbo-engines, reheat installation, and combustion chambers in gas turbines.

Compressor Design is Key to Napier Eland's Strong Points. A. J. Penn. *Av. Age*, Oct., 1956, pp. 28, 29, 30–33 ff. Details of the single-shaft turboprop designed for 3,000 e.hp. at a specific weight of 0.525 lb./e.hp. which is being developed to 4,200 e.hp. at a specific weight of 0.43 lb./e.hp.

Verdichterfertigung in einem neuzeitlichen Strahlturbinenwerk. *Luftfahrttechnik*, Sept. 15, 1956, pp. 169–173. In German. Discussion of SNECMA techniques used for the production and assembly of axial compressors for the Atar 101 engine.

Designing for the Automatic Control of Turbojet Engines. A. M. Wright. *Aero Dig.*, Sept., 1956, pp. 28–33. Analysis of a hydraulic-mechanical system used for the control of fuel admission, overspeed, and overtemperature.

Some Safety Aspects of Gas Turbines. M. G. Beard and F. W. Kolk. *Esso Air World*, July-Aug., 1956, pp. 8–11.

Criteria for Using Turbine Powerplants in Light Aircraft. Gilbert L. Roth. *Aero Dig.*, Sept., 1956, pp. 42–44.

Pure Jet v By-Pass. *Bristol Quart.*, Summer, 1956, pp. 49–52. Comparison between performance of by-pass and pure jets at sea level and upper altitudes.

Lycoming T53 Engine Designed for Versatility. *Av. Age*, Oct., 1956, pp. 26, 27. Description of the free-turbine type of engine for rotary and fixed-wing air-

craft which can have power-output shafts at either end.

Fuel Balance System for Supersonic Airplanes. John Karanik. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 2–6, 1956, Preprint 834.* 8 pp. Development of a fuel balance system to provide a reliable, lightweight, automatic method of monitoring fuel in order to remain within narrow limits set for the center of gravity movement.

The Specification and Testing of Fine Particle Filters; A Method of Defining the Performance of Filter Materials. R. W. Cranston and L. R. Beynon. *Aircraft Eng.*, Sept., 1956, pp. 318–321.

Service Problems Discussed at Bendix Aircraft Ignition Conference. Thomas MacNew. *Auto. Ind.*, Oct. 1, 1956, p. 66. Abridged. Review of the design, operation, and service of gas-turbine ignition systems.

Supersonic Age Poses Jet Installation Design Problems. A. C. Lovesey. *Av. Age*, Sept., 1956, pp. 28, 29, 30–35 ff.

The Propeller-Turbine in Airline Service. T. M. Corson. *J. RAeS*, Sept., 1956, pp. 590–604. Discussion of the engineering and operational aspects of the introduction and first 3 years' operation of the Rolls-Royce Dart.

Analyse du Fonctionnement Théorique da la Turbine à Gaz à l'Aide d'une Représentation Graphique. L. Poincaré. *Assoc. Tech. Marit. & Aéro., Paris, Session 1956.* 25 pp. In French. Application of a graphical representation to the theoretical analysis of the performance of a gas turbine.

A Program for the Developmental Testing of Turbo-Jet Aircraft Engines. Ephraim M. Howard. *GM Eng. J.*, Oct.-Nov.-Dec., 1956, pp. 12–19.

The High Temperature Turbo-Jet Engine. D. G. Ainley. *J. RAeS*, Sept., 1956, pp. 563–581; Discussion, pp. 581–589. 38 refs. Discussion of the major problems of high-temperature operation, with particular emphasis on the highly stressed turbine blades which are wholly submerged in the very hot gas stream.

The Design of Brittle-Material Blade Roots Based on Theory and Rupture Tests of Plastic Models. André J. Meyer, Jr., Albert Kaufman, and William C. Caywood. *U.S., NACA TN 3773*, Sept., 1956. 46 pp.

Analysis of Slip Damping with Reference to Turbine-Blade Vibration. L. E. Goodman and J. H. Klumpp. (*ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13–18, 1955.*) *J. Appl. Mech.*, Sept., 1956, pp. 421–429. 17 refs. Derivation of a general slip-damping theory and of an expression for the energy loss per cycle of oscillation. Analytical results are compared with those obtained through controlled experiments.

Ram-Jet & Pulse-Jet

Ramjet Development at Bristol. *Bristol Quart.*, Summer, 1956, pp. 35–39. Discussion of new facilities built by Bristol Aeroplane for ram-jet engine testing.

Reciprocating

Dobór Charakterystycznych Parametrów Konstrukcyjnych Silników z Komorami Wstępnymi. Kazimierz Niewiarowski. *Mechanika, Inst. Tech., Lodz*, No. 5, 1956, pp. 81–92. In Polish, with summaries in English and Russian. Method for the selection of characteristic constructional parameters for motors with precombustion chambers: the compression degree, relative size of the precombustion chamber, and the dimensions of the cross section of the canal connecting both parts of the burning space.

Wykreślno-Rachunkowe Wyznaczanie Czestości i Postaci Drgań Skrętnych Układów Korbowych Rzędowych Silników Spalivowych. Jerzy Jędrzejowski. *Mechanika, Inst. Tech., Lodz*, No. 5, 1956, pp. 35–80. 16 refs. In Polish, with summaries in English and Russian. Graphical and numerical determination of the frequency and form of torsional vibrations in the crank system of in-line combustion engines. Analysis is made of model mass-elastic complexes composed of a shaft segment with mass uniformly distributed along its whole length, one or two concentrated masses, and possibly a massless shaft segment. The nondimensional frequency of the torsional vibrations in these complexes is expressed by transcendental equations which are solved graphically and by numerical tables.

Rocket

Britain's First Variable-Thrust Rocket. *The Aeroplane*, Aug. 24, 1956, pp. 255–257, 259, 260. Developmental history, design and operating characteristics, and future potentialities of the Armstrong Siddeley Screamer.

Rocket-Motor Cases. *Aircraft Prod.*, Oct., 1956, p. 404. Discussion of the production of tubing for rocket motors using welded-together, low-alloy sheet steel.

Experimental Investigation of a Lightweight Rocket Chamber. John E. Dalgleish and Adelbert O. Tischler. *U.S., NACA TN 3827*, Oct., 1956. 11 pp. Test results showing the successful use of a jacketed rocket combustion chamber fabricated by hydraulic forming from sheet metal, with description of fabrication techniques.

Heat Transfer in Rockets. George P. Sutton. *J. Brit. Interplanetary Soc.*, July-Aug., 1956, pp. 192–205. 11 refs. General discussion of some applications of heat-transfer theory in rockets.

Production

Farnborough Report; Production Exhibits at the Annual Display of the Society of British Aircraft Constructors. *Aircraft Prod.*, Oct., 1956, pp. 406–417. Includes contour-etching, template manufacture, pneumatic hand tools, frozen-mercury casting, heater elements, heat-transfer panels, torque measurement, blade inspection, aluminum soldering, and stretch leveling.

New Materials and Processes Affecting Manufacturing Operations. George W. Papen. *Lockheed Aircraft Co., Paper*, 1956. 10 pp. Discussion of the effects of recent experimental developments on aircraft production methods, personnel, facilities, equipment, tooling, and design problems in the immediate future.

Flugzeugfertigung in kleinen Baureihen. H. Knickrehm. *Luftfahrttechnik*, Sept. 15, 1956, pp. 174–178. 27 refs. In German. Discussion of procedures used in the production of small series of aircraft.

Rocketry; An Interesting Study in New Production Techniques. *Bristol Quart.*, Summer, 1956, pp. 53–56. Discussion of production methods for rocket motor cases, with a description of sheet steel cutting, rolling, and arc-welding processes.

Metalworking

Castings Beat Forgings in Stress Tests. Randolph Hawthorne. *Av. Age*, Oct., 1956, pp. 102–103, 104—107 ff. Discussion of preliminary test results obtained by the USAF AMC Casting Potentials Projects whose fourfold purpose is to redesign aircraft components now used as forgings and fabrications for production as high-integrity castings, to find the best materials and processes for producing castings, to produce pilot castings for showing the feasibility of techniques and processes developed, and to determine the physical and chemical properties of castings.

Die Metallklebverbindung und ihre Bewertung für den praktischen Einsatz. E. Litz. *Luftfahrttechnik*, Sept. 15, 1956, pp. 162–168. 37 refs. In German. Discussion of metal-bonding techniques based on German experiences during the period 1952–1956.

A Review of the Heavy Press Program. John Alico. *Prod. Eng.*, Oct., 1956, pp. 135–140. Summary of the USAF-sponsored plan for the construction and operation of six extrusion and four forging presses.

Draw-Forming Techniques Contour Tapered Sections. *Tool Engr.*, Oct., 1956, p. 91. Description of methods involving the use of a Cyril Bath radial draw form machine with a transverse compression unit.

Pressure-Intensifiers. *Aircraft Prod.*, Oct., 1956, p. 405. Development of plastic overpress intensifiers to prevent wrinkles in rubber-die press forming.

Metody Badán Kalorymetrycznych nad Obróbką Skrawaniem. Zbigniew Kornberger. *Mechanika, Inst. Tech., Lodz*, No. 5, 1956, pp. 3–33. In Polish, with summaries in English and Russian. Analysis of the distribution of temperatures and of heat losses in a calorimeter used for studying resistance to cutting during drilling.

Machining Approach to Aircraft Production. H. F. Young. (*CAI Annual Gen. Meeting, Montreal, May 3, 4, 1956, Paper.*) *Can. Aero. J.*, Sept., 1956, pp. 252–258.

Setting Machine Slides; Numerical-Indicator Displaying the Distance Traversed by a Manually-Controlled Machine-Tool Slide. *Aircraft Prod.*, Oct., 1956, pp. 428, 429.

Internal Spline-Milling. *Aircraft Prod.*, Oct., 1956, pp. 434–436. Method of milling internal long grooves in tubular parts using a piloted boring-bar with a chain drive to the cutter in a lathe setup.

Production Engineering

Dial-Gauging. *Aircraft Prod.*, Oct., 1956, pp. 402, 403. Applications of dial-indicator gages in the inspection of gas-turbine blade assemblies.

Tooling

Ceramic Tools. *Aircraft Prod.*, Oct., 1956, pp. 426, 427. Evaluation of the tool life of ceramic and carbide cutting tools by comparison of machining tests.

Machine Conversion. L. G. Burnard. *Aircraft Prod.*, Oct., 1956, pp. 430–433. Description of a simple and inexpensive conversion of a plain, horizontal milling machine, previously used for light alloys, to the hydraulic copy-milling of high-tensile steel spars.

Jigless Drilling. *Aircraft Prod.*, Oct., 1956, pp. 418, 419. Description of a semi-automatic, pneumatically operated table for radial-drill applications.

Co-Ordinate Setting. Peter J. Farmer. *Aircraft Prod.*, Oct., 1956, pp. 394–399. Development of a simplified data-control system for automatically setting a work-table supported on compound slides at a preselected position.

Welding

Basic Characteristics of Some Heat-Resisting Brazing Filler Materials. W. H. Change. *Welding J. Res. Suppl.*, Sept., 1956, pp. 431-s–443-s. Investigation of four brazing filler materials for possible use in brazing for high-temperature applications. The evaluation is based on room-temperature tensile properties of butt-brazed joints. Materials tested are nickel-chromium-boron, nickel-chromium-silicon, and gold-nickel.

High Temperature Brazing of Gas Turbine Components. John V. Long, George D. Cremer, and Richard S. Mueller. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 2–6, 1956, Preprint 829.* 21 pp. Applications to jet-engine manufacture of high-temperature brazing, defined as a metallurgical joining process in which the filler metal has a melting point in excess of 1,600°F.

Carbon Migration in Welded Joints at Elevated Temperatures. R. J. Christoffel and R. M. Curran. *Welding J. Res. Suppl.*, Sept., 1956, pp. 457-s–468-s. Investigation of carbon migration during elevated temperature service for determining the propensity of a number of alloys to carbon migration, for developing a time-temperature relationship which would be capable of predicting the extent of carbon migration during service, and for determining the properties of welded joints aged to simulate the extent of carbon migration.

Notch Toughness of Weld Deposits in Commercial Titanium Alloys. S. M. Daley, Jr., and C. E. Hartbower. *Welding J. Res. Suppl.*, Sept., 1956, pp. 447-s–456-s. Investigation of the notch toughness of deposited weld metal and the heat-affected base metal which shows that acceptable toughness can be obtained in deposited metal and that the heat affected zones are inadequate.

Thermal Cutting of Aluminum, Stainless Steels, and High-Nickel Alloys. Edward H. Roper. *Welding J.*, Sept., 1956, pp. 915–920.

Propellers

Propellers for High Speed Aircraft. Daniel H. Jacobson and Robert A. Rogers. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 2–6, 1956, Preprint 820.* 15 pp. Discussion illustrating the reassessment of the controlling factors in propeller design for high-speed flight, as well as the part aerodynamic and structural compromises play in the overall propeller selection, and comparing the respective performances of turboprop and turbojet power plants on the basis of analytical and experimental data.

The First 21 Years; A Survey of de Havilland Propeller Manufacture from Its Beginning in 1935 to the Present Day. *de Havilland Gazette*, Aug., 1956, pp. 114–120.

Reference Works

Special Issue: Product Design Digest. *Prod. Eng.*, Mid-Oct., 1956. 806 pp. 88 refs. Continuation of the Product Design Handbook series with 104 articles covering: general engineering; metals and alloys; nonmetallic materials; fabrication and production processes; power transmission; mechanical parts and design analysis; fastening and joining; motors, engines, and controls; electrical and electronic components; and hydraulic and pneumatic equipment.

Rotating Wing Aircraft

Verkehrs- und Betriebswert des Hubschraubers heute und morgen. *Flugwelt*, Sept., 1956, pp. 594, 595. In German. Discussion of operational and flight data of helicopters in transport and industrial use—present and future.

Helicopter Developments During the Post-War Years; A Survey of the Advances Made in Helicopter Design, Construction and Operation. A. McClements and A. Armitage. *Aircraft Eng.*, Sept., 1956, pp. 290–303.

Electronic Instrumentation—A Flight Strain Gauge Recording Equipment for Helicopters. P. D. McMahon. *Saro Prog.*, Autumn, 1956, pp. 12–15. Description of equipment used to measure oscillatory and steady stresses on a helicopter rotor in flight.

The Effect of Compressibility on the Thrust and Power of a Helicopter Rotor. R. M. Head. *Douglas Rep. SM-18475*, Aug., 1954. 36 pp. Estimate based on strip theory and neglecting such higher order effects as the variation in inflow angle and inflow velocity over the rotor blade, the rotational interference due to slipstream rotation, and other considerations. Analysis includes determination of the effects of compressibility on the rotor in hovering flight to permit comparison with experimental data.

The Modes of Vibration of a Certain System Having a Number of Equal Frequencies. Appendix—**The Orthogonality Principle.** D. C. Johnson and R. E. D. Bishop. (*ASME Natl. Appl. Mech. Conf., Urbana, June 14–16, 1956.*) *J. Appl. Mech.*, Sept., 1956, pp. 379–384. Discussion of the dynamic behavior of a conservative system which represents an idealized bladed rotor whose principal modes are indeterminate, and description of a method of selecting suitable principal modes and coordinates. Analysis is applicable as an aid in understanding the behavior of a turbine disc which carries a large number of similar blades.

Some Examples of Laminar Boundary-Layer Flow on Rotating Blades. Nicholas Rott and William E. Smith. *J. Aero. Sci.*, Nov., 1956, pp. 991–996, 1,006. 12 refs. Application of the Fogarty and Falkner-Skan results to a number of specific examples involving both positive and negative pressure gradients in the chordwise direction.

Lo Strato Limite su Pale Rotanti. Marino Marini. *L'Aerotecnica* (Rome), June, 1956, pp. 218–222. In Italian. Derivation of equations for the laminar and incompressible boundary layer on a rotating blade, and examination of the methods used and of results obtained from various relevant investigations.

On the Damping in Pitch of a Helicopter Rotor in Forward Flight. David F. Gebhard and Leonard Goland. *J. Aero. Sci.*, Nov., 1956, pp. 1,051, 1,052. Results of theoretical investigation into the effect of advance ratio on the thrust moment.

Studies of the Speed Stability of a Tandem Helicopter in Forward Flight. Robert J. Tapscott and Kenneth N. Amer. *U.S., NACA Rep. 1260*, 1956. 12 pp. Supt. of Doc., Wash., $0.20. Evaluation of speed stability of a tandem rotor helicopter based on flight-test measurements, related analytical studies, and pilots' opinions.

Helicopter Test Rigs—A Unique Variety of Test Devices. *Bristol Quart.*, Summer, 1956, pp. 31–34. Description of test rigs used by Bristol to simulate flight operations. The equipment includes a rotor test tower and gantry rigs to test engines, gearboxes, and transmissions.

Safety

The Transport Airplane from the Pilot's Viewpoint. R. F. Adickes. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 2–6, 1956, Preprint 824.* 8 pp. Evaluation of design features of commercial aircraft and crew training procedures in terms of safety requirements.

Some of the Problems Associated with Aircraft Salvage Operations. II. K. J. Anderson. *J. SLAE*, July, 1956, pp. 3–12; Discussion pp. 12–14.

Space Travel

Researchers Probe Secrets of Flights 40 Miles Up. Irwin Stambler. *Av. Age*, Sept., 1956, pp. 36, 37, 38—41 ff. Survey of aerodynamic problems encountered in the upper atmosphere from 100,000 to 200,000 ft.

Stationary Trajectories for a High-Altitude Rocket with Drop-Away Booster. G. Leitmann. *Astronautica Acta*, Fasc. 3, 1956, pp. 119–124. Deduction of a solution to the problem of optimum thrust programing for a rocket which is required to reach a given altitude with given pay load (rather than given burnt mass) and minimum fuel expenditure.

Medical Problems Involved in Orbital Space Flight. Hubertus Strughold. *Jet Propulsion*, Sept., 1956, pp. 745–748, 756, 788. 36 refs.

Power Supplies and Telemetry for an Instrumented Artificial Satellite. I—Or-

ENGINEERS!

LIVE in Sunny San Diego!

THIS SOLAR ENGINEER'S WIFE SAYS:

"Since Tom accepted his position at Solar, our whole way of life has changed! I've never seen Tom so interested and content. I can tell, as only a wife can, how happy Tom is at Solar —because this happiness is reflected in the keen enjoyment with which he shares our family activities. San Diego's superb all-year climate has introduced us to a relaxed kind of living we never knew in the extreme heat and freezing cold of eastern seasons. Now we take full advantage of the outdoor living, recreational opportunities and cultural advantages. Here in sunny San Diego we really *live!* Tom's job at Solar is the luckiest break we've ever had!"

Whether you live by the sea, in the country, or in a residential suburb, you're within minutes of San Diego's many wonderful recreational opportunities.

You'll be delighted at the gay profusion of flowers and year-round beauty you'll find in San Diego every day of the year.

HIGH LEVEL ENGINEERS NEEDED

There are great advantages when you join Solar's Engineering Division. Your best abilities will be utilized on advanced development and production projects. You'll get wider engineering experience, for you'll be associated with a medium-size company, where you'll have a more varied diet of engineering problems and less specialization than in a larger firm.

Solar's excellent personnel policies offer a complete range of liberal benefits, including a profit sharing retirement plan. You can look forward to lifetime job security, for the extremely low turnover shows engineers choose Solar for long range careers. If you're seeking an exceptional career, send a resume of your qualifications and educational background to Louis Klein, Engineering Personnel, Dept. E-119, Solar Aircraft Company, 2200 Pacific Highway, San Diego 12, Calif.

SENIOR PROJECT ENGINEER
for Gas Turbines

CHIEF EXPERIMENTAL ENGINEER

PROJECT ENGINEERS
for Gas Turbines
Pneumatic Ducting

Solar also has permanent positions for:

CONTROLS ENGINEERS	DESIGN ENGINEERS
DESIGNERS	DRAFTSMEN
CHECKERS	ENGINEERING WRITERS

SOLAR
AIRCRAFT COMPANY

SAN DIEGO
DES MOINES

Designers, Developers and Manufacturers • Gas Turbines • Aircraft and Missile Components • Bellows • Controls • Coatings • Metal Alloy Products

THE REVOLUTIONARY NEW *Pack*

PUTS TRACINGS *at your fingertips!*

INTER LOCK FILE

SAVES TIME • MONEY • SPACE

Now, for the first time, a filing and storage system has been developed expressly for those hard-to-handle roll drawings, tracings, and prints. Here are just a few of the advantages:

SAVES TIME . . . puts important drawings at your fingertips

Now you can locate important tracings and drawings quickly and easily—without taking time to refer to a complicated file card system. With the Inter-Lock File each drawing is individually indexed right on the file door. A simple color coding system, visible right on the file door, helps you select the right file at a glance. Funnel-shaped front makes it easy to remove drawings.

SAVES SPACE . . . file more drawings in less space

Compact Inter-Lock Files can be used virtually anywhere—around existing files, in odd storage space, even stacked to the ceiling. No shelves or drawers are required, and there is no waste space. Can be added to as needed.

SAVES MONEY . . . keeps drawings in perfect condition

Drawings are completely protected from dust, light, and crushing; files are fire-resistant, too.

Available in sizes from 30" to 60". For complete information and prices call or see your nearest Dietzgen dealer.

Distributed by

DIETZGEN
EVERYTHING FOR DRAFTING, SURVEYING & PRINTMAKING

EUGENE DIETZGEN CO.

Chicago • New York • San Francisco
New Orleans • Los Angeles • Pittsburgh
Washington • Philadelphia • Milwaukee
Dealers in All Principal Cities

For further information, or address of nearest dealer, write or call...

PACK MANUFACTURING CO.
P. O. Box 508 • Logan, Utah

bital Considerations. E. C. White. II—**Instrumentation and Telemetry.** J. Foley. *J. Brit. Interplanetary Soc.*, July-Aug., 1956, pp. 177–191. Considerations of various possible satellite orbits with preference given to the one that will provide the vehicle with the most sunlight for its solar batteries.

The IGY Earth Satellite Program. Hugh Odishaw. *ISA J.*, Sept., 1956, pp. 298–301. Discussion of the objectives of the IGY and methods used to implement them. Includes description of proposed rocket and satellite operation and instrumentation.

The U.S. Satellite Vehicle Program. F. I. Ordway, III. *Astronautica Acta*, Fasc. 3, 1956, pp. 115–118. Outline of basic Vanguard satellite characteristics and expected performance.

What the Future Holds for the Earth Satellite. R. P. Haviland. *G-E Rev.*, Sept., 1956, pp. 10–15. Discussion of basic principles of launching an earth satellite, with details of celestial mechanics, trajectories and orbits around the earth, mapping and geodesy, weather charting and forecasting, and wireless communications.

Possibility of Using Artificial Earth Satellites for the Experimental Verification of the Theory of General Relativity. V. L. Ginzburg. (*Zhurnal Experimental'noi i Teoreticheskoi Fisiki*, Jan., 1956, pp. 213–214.) *Soviet Physics—JETP*, Aug., 1956, pp. 136–138. Translation.

The Potential Energy of a Small Rigid Body in the Gravitational Field of an Oblate Spheroid. R. E. Roberson and D. Tatistcheff. *J. Franklin Inst.*, Sept., 1956, pp. 209–214. Generalization of the extended McCullagh formula and application of the result to several special shapes of the subsidiary body, in order to provide the first step in the treatment of motions of such pairs of bodies in various special cases.

Studies of a Minimum Orbital Unmanned Satellite of the Earth (MOUSE). II—Orbits and Lifetimes of Minimum Satellites. S. F. Singer. *Astronautica Acta*, Fasc. 3, 1956, pp. 125–144. Description of the elliptical orbit of an artificial satellite in terms of the launching conditions, derivation of criteria for controlling these conditions, and analysis of the subsequent behavior of the orbit under the influence of the drag of upper atmosphere.

Structures

The Philosophy of Fail-Safe Design. E. H. LaBombard. *Douglas Serv.*, Sept.-Oct., 1956, pp. 1–10. Discussion of the structural arrangements in fail-safe design. These include redundant, double, back-up, and load-dropping structures.

The Automatic Design of Structural Frames. R. K. Livesley. *Quart. J. Mech. & Appl. Math.*, Sept., 1956, pp. 257–278. Description of an analytic method, suitable for use in conjunction with an electronic computer, which yields an extract solution for any numerical case associated with the general problem of determining the lightest structural frame of a given geometrical form to support a given set of loads. In-

cludes a description of programs developed for the Manchester University machine.

The Aircraft Fatigue Problem. *The Aeroplane*, Sept. 21, 1956, pp. 464, 465. Discussion of the problem including presentation of the fail-safe design concept; a review of fatigue loadings and fatigue in engines; and test results of fatigue loadings on 91 aircraft wings.

Combined Stress Creep Fracture of a Commercial Copper at 250 Deg. Cent. II. A. E. Johnson, J. Henderson, and V. D. Mathur. *The Engr.*, Aug. 31, 1956, pp. 299–301.

Boundary Value Problems for Elastic Circular Rings. Jozef Golecki. *Arch. Mech. Stosowanej* (Warsaw), No. 2, 1956, pp. 123–142. 10 refs. Derivation of a solution using the method of integrating Lamé's equations. The formulas obtained are concerned with the plane stress and plane strain of a multilayer ring with given displacements or forces at the boundaries.

Round Tubes in Bending. B. Saelman. *Mach. Des.*, Sept. 20, 1956, pp. 141–144. Presentation of design curves for the selection of optimum diameter and wall thickness for minimum weight.

Notes on the Practical Application of the Method of R.A.E. Report No. Structures 168. Appendix A—**Stringer-Reinforced Wing of Infinite Shear Stiffness - Station Reactions at Free Edges, Free Corners, etc.** Appendix B—**Boundary-Formulae for Approximate Method of Deriving Shear Deflections.** Appendix C—**Boundary-Station Formulae Appropriate to the More Exact Method.** D. Williams. *Gt. Brit., RAE Rep. Struc. 209*, 1956. 49 pp.

Bars & Rods

Zastosowanie Metody Małego Parametru do Określenia Siły Krytycznej Ściskanego Pręta o Zmiennym Przekroju Poprzecznym. Tadeusz Gałkiewicz. *Mechanika, Inst. Tech., Lodz*, No. 4, 1956, pp. 99–111. In Polish, with summaries in English and Russian. Application of the small-parameter method to the determination of critical force of a compressed bar with a variable cross section. Includes illustrative solutions for three different cases.

Stateczność Dynamiczna Prętów Osiowo Obciążonych o Dowolnie Zmiennym Przekroju. Marian Piątek. *Arch. Mech. Stosowanej* (Warsaw), No.1, 1956, pp. 51–68. 18 refs. In Polish, with summaries in English and Russian. Study of the dynamic stability of axially loaded bars with arbitrarily variable cross section.

Beams & Columns

Fatigue-Crack Propagation in Aluminum-Alloy Box Beams. Herbert F. Hardrath, Herbert A. Leybold, Charles B. Landers, and Louis W. Hauschild. *U.S., NACA TN 3856*, Aug., 1956. 33 pp. Experimental investigation of 18 box beams constructed according to four designs—two with stiffeners riveted to the cover, one with stiffeners bonded to the cover, and one with an integrally stiffened cover machined from a plate.

On the Stresses and Deflections of Rectangular Beams. B. A. Boley and I. S. Tolins. (*ASME Natl. Appl. Mech. Conf., Urbana, June 14–16, 1956.*) *J. Appl. Mech.*, Sept., 1956, pp. 339–342. Calculation of stresses and deflections from the two-dimensional elasticity theory by means of an iterative procedure. The loading consists of either normal or shear forces varying smoothly along the span.

On the Flexure of a Stepped Cantilever Beam. E. Edryd Jones. *J. Aero. Sci.*, Nov., 1956, pp. 1,057, 1,058. Analysis of the flexure of a nonuniform beam with prescribed end conditions and loads to derive a theory for the stepped cantilever beam which is readily adapted to numerical interpretation and which may be extended to cover point loads, point moments, and distributed moments.

Experimental Investigation of the Strength of Multiweb Beams with Corrugated Webs. Allister F. Fraser. *U.S., NACA TN 3801*, Oct., 1956. 17 pp.

Wpływ Zamocowania Zupełnego na Naprężenia w Dźwigarze Zginanym. Jerzy Nowiński. *Glown. Inst. Lotnictwa, Prace*, No. 1, 1951, pp. 59–67. In Polish. Calculation of the influence of end-constraint on stresses and deflexions of the free end of a beam in flexion, taking into account four or three self-equilibrating systems. Analysis considers a thin rectangular beam bent by a concentrated load at the free end, and assumes suitable expressions for the stresses constituting self-equilibrating systems in the built-in end of the beam, in order to eliminate the warping of the end cross section caused by the load.

Time-Dependent Tangent Modulus Applied to Column Creep Buckling. R. L. Carlson. (*ASME Natl. Appl. Mech. Conf., Urbana, June 14–16, 1956.*) *J. Appl. Mech.*, Sept., 1956, pp. 390–394. 19 refs. Abridged. WADC-sponsored discussion of typical cases, citing experimental results for classifying the relation of the time-dependent tangent-modulus load, as conceived by Shanley, to actual column capacity.

Thin-Walled Doubly Curved Structural Elements with High Taper. J. Nowiński. *Bul. Acad. Polonaise Sci.* (Warsaw), No. 2, 1956, pp. 87–90. Derivation of a theory for doubly curved, high-taper thin-walled beams, based on three assumptions: (1) the cross sections are not deformable in their planes, (2) the axis of the beam is a straight line perpendicular to the plane of fixing, and (3) the middle surface of the wall is a surface of revolution the axis of which coincides with that of the beam.

Belki Krzywoliniowe z Profili Cienkościennych Otwartych. Piotr Wilde. *Arch. Mech. Stosowanej* (Warsaw), No. 1, 1956, pp. 41–50. In Polish, with summaries in English and Russian. Analysis of a double-tee girder curve in the horizontal plane. A differential equation of the deflection curve is derived by means of the principle of virtual work.

Cylinders & Shells

Stress Analysis of Circular Semimonocoque Cylinders with Cutouts. Appendix A—**Summary of Significant Equations.** Appendix B—**Bending Moment, Axial Thrust, and Transverse Shear in Rings.** Appendix C—**Evaluation of Definite Integrals.** Harvey G. McComb, Jr. *U.S., NACA Rep. 1251*, 1955. 55 pp. 10 refs. Supt. of Doc., Wash., $0.45.

Effects of Boundary Conditions and Initial Out-of-Roundness on the Strength of Thin-Walled Cylinders Subject to External Hydrostatic Pressure. Appendix—**Approximate Equations of Equilibrium for an Initially Out-of-Round Cylinder.** G. D. Galletly and R. Bart. (*ASME Natl. Appl. Mech. Conf., Urbana, June 14–16, 1956.*) *J. Appl. Mech.*, Sept., 1956, pp. 351–358. 16 refs.

Teoria Dźwigarów Cienkościennych Zbieżnych. Jerzy Nowiński. *Glown. Inst. Lotnictwa, Prace*, No. 1, 1951, pp. 3–47. 14 refs. In Polish. Analysis to derive a theory of cantilever tubes in the absence of buckling. Approximate general expressions are formulated for the coordinates of the axes of shear neglecting the influence of self-equilibrating stress systems, and solutions are found for the case of torsion by a concentrated torque in an arbitrarily chosen section, and for that of bending combined with torsion caused by a force in an arbitrarily chosen section.

Metoda Utwierdzenia Sprężystego w Konstrukcjach Lotniczych. Zbigniew Brzoska. *Inst. Lotnictwa, Prace*, No. 2, 1955. 69 pp. In Polish. Description of the elastic-clamping method of solution for highly redundant aircraft structures.

Strength of a Tube Under Local External Pressure. G. R. Higginson. *The Engr.*, Sept. 28, 1956, pp. 428–430. Analysis of a long tube subject to external pressure over a short, finite length, under the assumption that the material is ideally plastic and that it obeys the Levy-Mises stress-strain relations.

The Strength of Tubes Under Uniform External Pressure. P. C. Cleaver. *Gt. Brit., ARC CP 253* (Nov., 1955), 1956. 181 pp. 29 refs. BIS, New York, $4.86. Experimental investigation to check the validity of Sturm's solution for the simple end constraint and lateral pressure case, and the effects of relevant mechanical properties on collapse pressure. Includes 530 tests covering ranges of length/diameter from 14.0 to 0.51 and nominal thickness/diameter from 0.0098 to 0.056.

Skręcanie Rury Cienkościennej o Przekroju Prostokątnym Poza Granicą Sprężystości. Jersy Rutecki. *Arch. Mech. Stosowanej* (Warsaw), No. 1, 1956, pp. 29–40. In Polish, with summaries in English and Russian. Solutions for the torsion of a thin-walled rectangular tube beyond the elastic limit, assuming suitable diagrams for direct and shear stresses in the state of limit strength. Assumptions are in agreement with diagrams for the elastic state, the condition of equilibrium, and the Huber-Mises-Hencky yield condition. Relations are derived between the values of the bimoment, the bending-twisting moment, and the twisting moment.

The Limit Load of a Thick-Walled Tube in a General Circularly Symmetrical Case. Michał Życzkowski. *Arch. Mech. Stosowanej* (Warsaw), No 2, 1956, pp. 155–178. 36 refs. Theoretical analysis assuming a linear system and an incompressible material that is homogeneous and isotropic both in the elastic and the plastic range. Mass forces and thermal loads are neglected. Results make possible the estimate of the influence of wall thickness and

the prediction of conditions under which the tube considered can be regarded as thin-walled.

Zginanie Zakrzywionej Rury Cienkościennej Zaopatrzonej we Wręgi. Jerzy Nowiński. *Glown. Inst. Lotnictwa, Prace,* No. 1, 1951, pp. 49–57. In Polish. Theoretical determination of the elastic distortion in the case of tubes with perfectly rigid diaphragms at both ends, based on von Kármán's solution for the bending of a curved thin circular tube, and taking into account the influence of diaphragms by assuming suitable expressions for the function representing the flattening of cross section. Analysis considers two cases—that of articulated diaphragms and that of rigidly fixed diaphragms.

O Zastosowaniu Przekształcenia Laplace'a do Zagadnien Skręcania Prętów Cienkościennych. Jerzy Nowiński. *Arch. Mech. Stosowanej* (Warsaw), No. 1, 1956, pp. 111–119. 12 refs. In Polish, with summaries in English and Russian. Application of the Laplace transformation to the Vlasov's theory of thin-walled tubes in order to solve problems of torsion.

Equations of the Engineer's Non-Linear Theory of Thin Shells. Zdzisław Parszewski. *Arch. Mech. Stosowanej* (Warsaw), No. 2, 1956, pp. 143–154.

A Survey of Recent Progress in the Theory of Elastic Shells. P. M. Naghdi. *Appl. Mech. Rev.*, Sept., 1956, pp. 365–368. 46 refs. Review of the general theory of shells, as well as some applications which employ new methods of solution or which are contributive to the development of the theory.

Elasticity & Plasticity

Ortotropia i Niejednorodność w Teorii Plastyczności. W. Olszak and W. Urbanowski. *Arch. Mech. Stosowanej* (Warsaw), No. 1, 1956, pp. 85–110. 23 refs. In Polish, with summaries in English and Russian. Study of the orthotropy and the nonhomogeneity in the theory of plasticity.

A Modified Incremental Strain Law for Work-Hardening Materials. W. H. Warner and G. H. Handelmann. *Quart. J. Mech. & Appl. Math.*, Sept., 1956, pp. 279–293. 13 refs. WADC-supported development of a generalization of the Hodge, Prager, and Drucker incremental strain law to afford the possibility of several different types of loading regions in contrast to a single loading or unloading region of the older theories, and to permit explicit inversion of the stress-strain relations and proof, in the Greenberg manner, of minimum principles for the stress and strain rates.

The Propagation of Fatigue Cracks. A. K. Head. (*ASME Natl. Appl. Mech. Conf., Urbana, June 14–16, 1956.*) *J. Appl. Mech.*, Sept., 1956, pp. 407–410. Extension of the theory of the rate of growth of fatigue cracks to the case of large stresses. Discussion of recent McClintock and Ryan measurements is included.

Elastic Isotropy with Body Force and Couple. R. Tiffen and A. C. Stevenson. *Quart. J. Mech. & Appl. Math.*, Sept., 1956, pp. 306–312. Analysis tracing the consequences of the assumption of body couple in classical infinitesimal elasticity and examination of the mechanism of action across an interface in a continuous medium with special reference to a new multiconstant controversy in the theory of elasticity.

Studies on Plastic Flow of Anisotropic Metals. L. W. Hu. (*ASME Diamond Jubilee Annual Meeting Chicago, Nov. 13–18, 1955.*) *J. Appl. Mech.*, Sept., 1956, pp. 444–450. 19 refs. Extension of Hill's theory of plastic flow of anisotropic metals in order to develop plastic stress-strain relations for anisotropic materials with strain hardening.

On the Fundamentals of the Theory of Elasticity of Physically Non-Linear Non-Homogeneous Bodies. W. Olszak and M. Życzkowski. *Bul. Acad. Polonaise Sci.* (Warsaw), No. 2, 1956, pp. 63–72. 13 refs. Analysis of nonlinear nonhomogeneous bodies neglecting the assumption of material's incompressibility commonly accepted in the theory of plasticity. Results of research on physically linear nonhomogeneous bodies are taken into consideration.

An Elastoplastic Thermal-Stress Analysis of a Free Plate. Appendix—**Derivation of Approximate Temperature Distribution.** Jerome Weiner. (*ASME Natl. Appl. Mech. Conf., Urbana, June 14–16, 1956.*) *J. Appl. Mech.*, Sept., 1956, pp. 395–402. USAF-sponsored modification of the known elastic solution to derive a heuristic solution which is verified to satisfy all the conditions of the appropriate uniqueness theorem and to represent, therefore, the unique solution to the problem.

Solution of the Plane Problem of the Theory of Elasticity in Rectangular Co-Ordinates, Body Forces Being Taken into Consideration. F. Szelągowski. *Bul. Acad. Polonaise Sci.* (Warsaw), No. 2, 1956, pp. 105–110.

Plastic Twisting of Thick-Walled Circular Ring Sectors. W. Freiberger and W. Prager. (*ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13–18, 1955.*) *J. Appl. Mech.*, Sept., 1956, pp. 461–463. Description of a graphical method for determining the fully plastic stress distribution in a twisted circular ring sector with hollow cross section, as well as the warping of the cross section of this ring in the ensuing plastic flow, assuming a ring that consists of a rigid, perfectly plastic material.

Plates

Orthotropic Rectangular Plates with Arbitrary Boundary Conditions. Zbigniew Kączkowski. *Arch. Mech. Stosowanej* (Warsaw), No. 2, 1956, pp. 179–196. Derivation of a double trigonometric-series expression for the deflection surface.

Buckling of Rectangular Plates Uniformly Compressed in Two Perpendicular Directions with one Free Edge and Opposite Edge Elastically Restrained. P. Shuleshko. (*ASME Natl. Appl. Mech., Conf., Urbana, June 14–16, 1956.*) *J. Appl. Mech.*, Sept., 1956, pp. 359–363.

The Buckling Shear Stress of Simply-Supported, Infinitely-Long Plates with Transverse Stiffeners. P. W. Kleeman. *Gt. Brit., ARC R&M 2971* (Jan., 1953), 1956. 18 pp. BIS, New York, $0.90. Theoretical investigation of plates with stiffeners spaced at regular intervals, dividing the plate into a number of panels of uniform size, in order to calculate the stresses for all combinations of the bending and torsional stiffness of the stiffeners.

Naprężenia Montażowe w Płytach. Witold Nowacki. *Arch. Mech. Stosowanej* (Warsaw), No. 2, 1956, pp. 215–232. In Polish, with summaries in English and Russian. Analysis of the assemblage stresses in plates, considering a plate which has a slight initial curvature.

Bending of a Uniformly Loaded Semicircular Plate Simply Supported Around the Curved Edge and Free Along the Diameter. D. F. Muster and M. A. Sadowsky. (*ASME Natl. Appl. Mech. Conf., Urbana, June 14–16, 1956.*) *J. Appl. Mech.*, Sept., 1956, pp. 329–335. 10 refs.

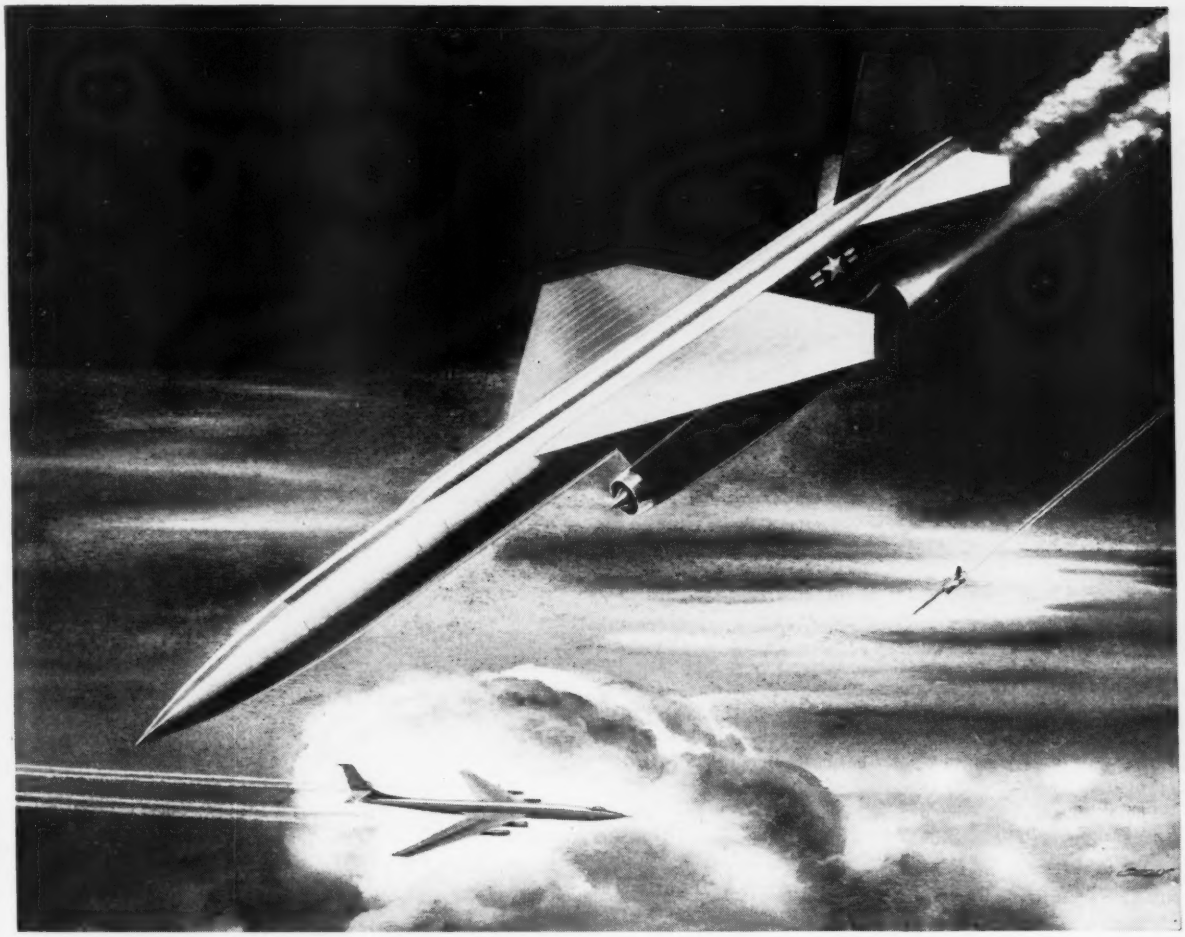
Płyta Kołowa na Obwodzie Częściowo Utwierdzona Zupełnie i Częściowo Swobodnie Podparta. Witold Nowacki and Zbigniew Olesiak. *Arch. Mech. Stosowanej* (Warsaw), No. 2, 1956, pp. 233–235. In Polish, with summaries in English and Russian. Analysis of the problem of a circular plate partially clamped and simply supported along the periphery, considering the forced vibrations of such a plate subjected to an additional compressive load acting in its middle plane.

O Pewnym Przypadku Utraty Stateczności Płyty Prostokątnej Obciążonej Siłami Skupionymi. Władysław Walczak. *Mechanika, Inst. Tech., Lodz,* No. 4, 1956, pp. 89–97. In Polish, with summaries in English and Russian. Theoretical investigation of an isotopic rectangular plate of constant thickness freely supported along its edges in its middle plane and loaded with a concentrated force applied at any point on its axis of symmetry, in order to derive a simple formula for the critical value of the compressing force as a function of constant factors, from the expression for the middle surface of the plate represented in trigonometric-series form, and by applying Timoshenko's energy method.

Problem of Large Deflection of Circular Plate. Wei-Zang Chien. *Arch. Mech. Stosowanej* (Warsaw), No. 1, 1956, pp. 3–12. 10 refs. Analysis using von Kármán's equations for large deflections, solved by a method of successive approximation based upon a small parameter related to the ratio of deflection to thickness.

Drgania Swobodne i Wyboczenie Płyty Trójkątnej. Zbigniew Kączkowski. *Arch. Mech. Stosowanej* (Warsaw), No. 1, 1956, pp. 13–28. In Polish, with summaries in English and Russian. Analysis to determine free vibration and buckling of an isotropic square plate resting on an elastic foundation and loaded with uniformly distributed normal forces. The deformed surface of the plate is represented by a double Fourier series which is antimetric with respect to a diagonal and, therefore, satisfies the boundary conditions of simple support for all edges and for the diagonal.

Stress Solutions for an Infinite Plate with Triangular Inlay. R. M. Evan-Iwanowski. (*ASME Natl. Appl. Mech. Conf., Urbana, June 14–16, 1956.*) *J. Appl. Mech.*, Sept., 1956, pp. 336–338. Application of Goursat's method for solving two-dimensional problems in elasticity by means of the functions of complex variables to (a) an infinite plate with a



Boeing "Aeros" help develop new defense weapons system

Boeing's BOMARC IM-99 is a long-range guided missile designed to strike enemy bombers while still over areas away from vital targets. It's a supersonic spearhead of an entire defense weapons system that includes communications, bases, logistics.

Aeronautical engineers at Boeing have made major research contributions toward the development of this vital weapons system. Their guided missile work, most of it at the very frontiers of knowledge, includes supersonic and hypersonic design, autopilot - aerodynamic - systems analysis, flooder - aeroelastic - aerodynamic stability, and missile flight test data analysis. If this kind of pioneering appeals to you, and if you enjoy working with engineers of outstanding professional stature, you'll like Boeing.

And you'll find plenty of room for advancement. Boeing's growth — a 400% jump in the number of Boeing engineers in the last 10 years — assures openings ahead, and job stability. Boeing promotes from within, and every six months a merit review gives each engineer a *personal* opportunity for recognition, advancement, increased income.

Starting salaries at Boeing are high, and the company pays moving and travel expenses. If you are interested in continuing graduate studies, Boeing will arrange a special work schedule for you and pay all tuition and fees. Other Boeing advantages include a liberal retirement program and the backing of outstanding research and test facilities. Your family will enjoy life in any of the three young-spirited communities in which Boeing is located. Pick the climate and living advantages that suit you best. Each offers an abundance of recreational activities, plus good housing, schools, convenient shopping centers.

You'll be proud to be associated with a leader in one of the most exciting—and promising — industries in the country. The first step is simple, and it'll pay you to take it now: fill out the coupon and get it in the mail, today!

JOHN C. SANDERS, Staff Engineer — Personnel
Boeing Airplane Co., Dept. A-58, Seattle 24, Wash.

F. B. WALLACE, Staff Engineer—Personnel
Boeing Airplane Co., Dept. A-58, Wichita, Kansas

A. J. BERRYMAN, Manager — Administration
Boeing Airplane Co., Dept. A-58, Melbourne, Fla.

Mail this coupon to the address above from which you desire further information about advantages of a Boeing career.

Name_____

College(s)_____ Degree(s)____ Year(s)____

Address_____

City_____ Zone____ State_____

Telephone number_____

BOEING

Aviation leadership since 1916

SEATTLE, WASHINGTON WICHITA, KANSAS
MELBOURNE, FLORIDA

rigid triangular inlay under uniform tension at infinity, (b) a concentrated force, and (c) a moment acting on a triangular inlay in an infinite plate.

A Study of Orthogonally Stiffened Plates. W. H. Hoppmann, N. J. Huffington, Jr., and L. S. Magness. (*ASME Natl. Appl. Mech. Conf., Urbana, June 14–16, 1956.*) *J. Appl. Mech.*, Sept., 1956, pp. 343–350. Extension of previous analytical theory and method to include additional study of theoretically and experimentally determined frequencies of vibration and strain distributions. Results presented as curves and tables indicate that the method should be given serious consideration for design application.

Sandwich Structures

A Study of the Efficiency of High-Strength, Steel, Cellular-Core Sandwich Plates in Compression. Aldie E. Johnson, Jr., and Joseph W. Semonian. *U.S., NACA TN 3751*, Sept., 1956. 26 pp. 12 refs. Theoretical investigation with results in the form of efficiency curves applicable for determining optimum proportions of sandwich plates for any value of compressive loading intensity. Includes comparison between the efficiency of optimum-proportional steel sandwich plates and solid plates of high-strength steel, and of aluminum and titanium alloys at 80° and 600°F.

Testing

PhotoStress. F. Zandman and Marc R. Wood. *Prod. Eng.*, Sept., 1956, pp. 167–177. Description of a photoelastic stress analysis technique in which the structure to be investigated is coated with a special clear plastic that becomes doubly refractive when stressed, revealing (under polarized light) the overall distribution of surface in the form of black and color fringes in the plastic, and permitting the observation and recording of the magnitude and direction of the strains when the coating is used in conjunction with especially designed reflection polariscopes.

Techniques and Problems in Testing Structures at Elevated Temperatures. Lewis H. Abraham. (*IAS Natl. Summer Meeting, Los Angeles, June 18–21, 1956, Preprint 640.*) *Aero. Eng. Rev.*, Nov., 1956, pp. 56–60. Discussion of testing methods and loading techniques for high-temperature testing of materials.

Thermal Stress

A Re-Evaluation of Some Air-Frame Thermal Problems. Norris F. Dow. (*IAS Natl. Summer Meeting, Los Angeles, June 18–21, 1956, Preprint 639.*) *Aero. Eng. Rev.*, Nov., 1956, pp. 61–66. 17 refs. Discussion of material selection, thermal stresses, and creep in high-speed aircraft structures.

Thermal Stresses in Airplane Wings Under Constant Heat Input. Frederick V. Pohle and Irwin Berman. *USAF WADC TN 55-330*, July, 1956. 43 pp. 23 refs. Theoretical investigation to extend previous analyses for nonconstant boundary-layer temperature to the treatment of a wide range of geometrical parameters in order to provide results, in the form of graphs for a specific model for which test data are available, that will be practical for design work.

On the Thermoelastic Problem in the Case of Bodies of any Type of Curvilinear Orthotropy. J. Nowiński, W. Olszak, and W. Urbanowski. *Bul. Acad. Polonaise Sci.* (Warsaw), No. 2, 1956, pp. 97–104. Application of the analogy of thermal load (as proposed by Duhamel and Neumann) to bodies of any type of curvilinear orthotropy.

Investigation of the Temperature Distribution and Thermal Stresses in a Hypersonic Wing Structure. Martin A. Goldberg. (*IAS 24th Annual Meeting, New York, Jan. 23–26, 1956, Preprint 576.*) *J. Aero. Sci.*, Nov., 1956, pp. 981–990. 15 refs.

Thermal Buckling of Supersonic Wing Panels. N. J. Hoff. *J. Aero. Sci.*, Nov., 1956, pp. 1,019–1,028, 1,050. WADC-sponsored theoretical investigation of the temperature and thermal stress distributions in multicellular wing structures in order to establish a buckling criterion for the panels of cover plates subject to thermal stresses.

Naprężenia Cieplne w Powłokach Walcowych. Witold Nowacki. *Arch. Mech. Stosowanej* (Warsaw), No. 1, 1956, pp. 69–83. In Polish, with summaries in English and Russian. Calculation of the thermal stresses in a circular cylindrical shell due to the temperature increase which varies linearly across the thickness of the shell.

Thermodynamics

Thermodynamic Charts for High Temperature Air Calculations (2,000°K to 9,000°K). J. G. Logan, Jr. *Cornell Aero. Lab. Rep. AD-1952-A-3* (*AFOSR TN 56-342*), July, 1956. 25 pp.

Concerning Some Thermodynamic Inequalities. V. P. Silin. (*Zhurnal Experimental'noi i Teoreticheskoi Fisiki*, Jan., 1956, pp. 197–199.) *Soviet Physics—JETP*, Aug., 1956, pp. 123–125. Translation. Derivation of the thermodynamic inequalities which are the necessary conditions for thermodynamic equilibrium, in order to obtain results pertaining to the form of the equilibrium curve of the magnetization of a magnet.

Combustion

The Oxidation, Decomposition, Ignition, and Detonation of Fuel Vapors and Gases. XXIX—The Role of Nuclei in the Ignition by Compression of Gaseous Heptane-Air Mixtures: First Paper. R. O. King and A. B. Allan. *Can. J. Tech.*, Sept., 1956, pp. 316–334. 11 refs. Experimental investigation using a C.F.R. carburetor engine with a special adjustable-temperature plug protruding into the combustion chamber to provide a surface at temperatures higher, lower, or equal to that of the exhaust valve whether it is uncooled or sodium cooled. The compression ratio is always adjusted for maximum power output which varies with the temperature of the exhaust valve as well as with mixture strength.

Turbulent Burning Velocities of Natural Gas-Air Flames with Pipe-Flow Turbulence. J. Kenneth Richmond, Joseph M. Singer, E. B. Cook, James R. Oxendine, Joseph Grumer, and David S. Burgess. *U.S., Bur. Mines TR 1205* (*AFOSR TN 56-238*), Apr. 30, 1956. 27 pp. 10 refs. Measurements of burning velocity as function of height in Bunsen flames in order to test existing theories of turbulent burning velocity and to search for flame-generated turbulence.

Low Pressure Performance of Cylindrical Can Burners. Malcolm A. Weiss and John P. Longwell. *Jet Propulsion*, Sept., 1956, pp. 749–756. Experimental investigation to determine the combustion stability and efficiency of can burners with one, two, and three stages of inlet holes, including tests to determine the effects of varying the number and size of first-stage inlet openings, the diameter and length of the recirculation zone, and changing pressure, mass flow, inlet-jet direction, recirculation-zone wall temperature, and tailpipe length.

Probe Studies of Rarefied Flames. V. I. Tverdokhlebov. (*Zhurnal Experimental'noi i Teoreticheskoi Fisiki*, Feb., 1956, pp. 252–255.) *Soviet Physics—JETP*, Sept., 1956, pp. 252–254. 10 refs. Translation. Experimental investigation of the electrical properties of flames under pressures of 30 to 50 mm. Hg by means of a probe similar to that used by Heumann in studies of flames burning under atmospheric pressures, and introduction of an assumption about the ionization mechanism in the reacting zone of the flame.

The Viscosity of Mixtures of Gases at High Temperatures. M. J. Kenney, R. J. Sarjant, and M. W. Thring. *J. Appl. Phys.*, Sept., 1956, pp. 324–329. 37 refs. Determination of viscosities of products of fuel combustion for heat-transfer calculations.

Heat Transfer

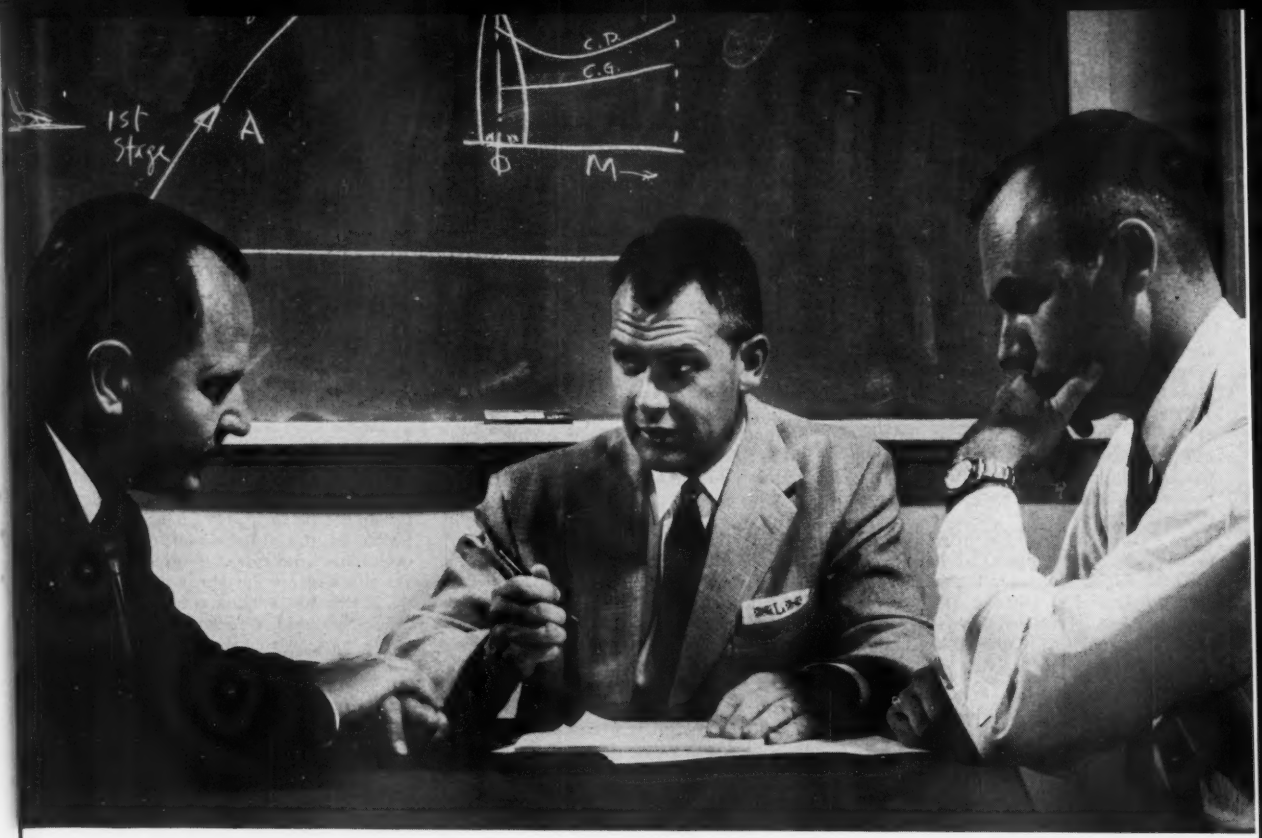
Heat Conductivity in Polyatomic, Electronically Excited, or Chemically Reacting Mixtures. III. Joseph O. Hirschfelder. *U. Wis. NRL Dept. Chem. Rep. CM-880*, Aug. 15, 1956. 40 pp. 13 refs. Survey of theoretical problems involved in estimating the heat conductivity of a chemically reacting gas or gas mixture.

A Propos de Quelques Expériences Récentes sur la Convection de la Chaleur et la Transformation de l'Énergie. Pierre Vernotte. *France, Min. de l'Air PST 61*, 1956. 21 pp. SDIT, 2 Av. Porte-d'Issy, Paris 15, Frs. 250. In French. Discussion of recent experiments on heat convection and transformation of energy.

Studies for a New Hot Air Engine. III—Fundamentals of Heat Exchanger Operation with Oscillating Flow. H. A. Havemann, N. N. Narayan Rao, P. Jayachandra, and G. C. Garg. *J. Indian Inst. Sci., Sect. B*, July, 1956, pp. 172–202. 27 refs.

VTOL & STOL

The Aerodyne—A New Concept of Flight. A. M. Lippisch. (*IAS Meeting, Wash., Dec. 13, 1955.*) *Collins Aero. Res. Lab., Paper.* 42 pp. Theoretical analysis of a vehicle for flight at zero forward speed producing its lift and propulsion from one cannon source of energy through



L. K. Edwards (center), advanced design and systems analysis department head, discusses launching of a ballistic missile with W. P. Gruner (left), head of weapons systems integration, and Systems Analyst G. W. Flynn.

the creative approach to MISSILE SYSTEMS ANALYSIS

There are few areas in which engineers and scientists can apply their abilities so broadly as in Lockheed's concept of systems analysis. Lockheed systems analysis staff members engage importantly in virtually every phase of missile preliminary design and development as they:

- formulate overall analytical treatment
- perform original analyses when problems defy conventional handling
- coordinate analytical activities among different departments

Because Lockheed is involved primarily in frontier activities, its systems analysis emphasis is on new approaches, new techniques, new ideas. It is work that calls for flexible, creative minds.

Inquiries are invited from engineers and scientists possessing those attributes. Positions are open at both Van Nuys and Sunnyvale, California, centers.

Lockheed

MISSILE SYSTEMS DIVISIC

research and engineering staff

LOCKHEED AIRCRAFT CORPORATION

VAN NUYS • PALO ALTO • SUNNYVAI

CALIFORNIA

an internal flow system. This system employs a shrouded propeller intake and a movable cascade for outflow to produce lift and change of direction.

Lift and Thrust Creating Systems—Their Application to Short- and Vertical-Takeoff Aircraft. F. C. Phillips and K. Irbitis. (*CAI Annual Gen. Meeting, Montreal, May 3, 4, 1956, Paper.*) *Can. Aero. J.*, Sept., 1956, pp. 235–246.

Transition-Flight Tests of a Model of a Low-Wing Transport Vertical-Take-Off Airplane with Tilting Wing and Propellers. Powell M. Lovell, Jr., and Lysle P. Parlett. *U.S., NACA TN 3745*, Sept., 1956. 30 pp. Investigation of the stability and control of a remotely controlled model during the transition from hovering to normal flight. The wing of the model can be rotated to 90° incidence during flight so that the propeller thrust axes are vertical for hovering flight.

STOL-VTOL Aircraft in the Air Mobile Army. Michael J. Strok. (*IAS Natl. Summer Meeting, Los Angeles, June 18–21, 1956, Preprint 646.*) *Aero. Eng. Rev.*, Nov., 1956, pp. 81–85.

Water-Borne Aircraft

Experiments on Circular Arc and Flat Plate Hydrofoils in Noncavitating and Full Cavity Flows. Blaine R. Parkin. *CIT Hydrodynamics Lab. Rep. 47-6*, Feb., 1956. 48 pp.

The Full-Scale Hydrodynamic Performance of a Large Four-Engined Flying Boat at Overload in Calm Water and Swell. J. A. Hamilton and R. V. Gigg. *Gt. Brit., ARC R&M 2898* (Aug., 1952), 1956. 38 pp. BIS, New York, $1.89. Investigation using a Solent flying boat in sheltered water and in open-sea swells of height up to 5 ft.

Skin Friction Formulations. Paul S. Granville. *U.S., Navy Dept., David W. Taylor Model Basin, Rep. 1063*, July, 1956. 6 pp. Description of a linearized diagram of the total coefficient of resistance in terms of the coefficient of flat-plate resistance, and derivation of a general resistance formula for flat plates based on the similarity laws of boundary-layer flow: the inner and outer laws of the mean-velocity profile.

Wind Tunnels & Research Facilities

7th NATO AGARD Wind-Tunnel and Model-Testing Panel Meeting, Ottawa, June, 1955. Publ. in Paris; Wash., Distrib. in U.S. by NACA, 1956. 331 pp. 188 refs. Contents: The Representation of Engine Airflow in Wind Tunnel Model Testing, J. Seddon and L. F. Nicholson. The Influence of Turbojet Airflow on the Aerodynamic Design of Airplanes, Harold Luskin and Harold Klein. The Simulation of the Effects of Internal Flow in Wind Tunnel Model Tests of Turbojet Powered Aircraft, Albert J. Evans. Boundary Layers on Swept Wing; Their Effects and Their Measurement, D. Küchemann. The Use of Pitot Tubes in the Measurement of Laminar Boundary Layers in Supersonic Flow, R. J. Monaghan. Méthode de Calcul de la Couche Limite Tridimensionnelle; Application à un Corps Fuselé Incliné sur le Vent, E. A. Eichelbrenner and O. Oudart. A Brief Review of Three-Dimensional Boundary-Layer Flow, W. R. Sears. The Simulation and Measurement of Aerodynamic Heating at Supersonic and Hypersonic Mach Numbers, Jackson R. Stalder and Alvin Seiff. The Status of Heat Transfer and Friction Investigations at Supersonic Speeds, H. H. Kurzweg. The N.R.C. Icing Wind Tunnels and Some of Their Problems, C. K. Rush. Wind Tunnel Simulation of Atmospheric Icing Conditions, C. K. Rush and R. L. Wardlaw. The Fluid Flow Associated with the Impact of Liquid Drops with Solid Surfaces, P. Savic and G. T. Boult. The Icing Problem–Current Status of N.A.C.A. Techniques and Research, Uwe H. von Glahn.

The Air Force Flight Test Center. Robert M. Caldwell. *Sperryscope*, Third Quarter, 1956, pp. 12–15.

Redstone Arsenal: Army Ordnance Center for Guided Missiles. H. N. Toftoy. *Sperryscope*, Third Quarter, 1956, pp. 2–5.

Some Comments on Surface Contamination in Hydraulic Analogy Research. R. A. A. Bryant. *J. Aero. Sci.*, Nov., 1956, pp. 1,056, 1,057. Description of a technique to produce an uncontaminated water surface and discussion of obtained data.

On the Status of Complex Wave Generation in Model Tanks. Wilbur Marks. *U.S., Navy Dept., David W. Taylor Model Basin, Rep. 1069*, July, 1956. 22 pp. 19 refs.

A Rotating Arm and Maneuvering Basin. W. F. Brownell. *U.S., Navy Dept., David W. Taylor Model Basin, Rep. 1953*, July, 1956. 73 pp. Description of new installations and design information concerning the test facilities, electric drives, auxiliary equipment, and instrumentation.

Test Facilities—Aeronautical Turbine Laboratory; Facilities and Test Services Provided at the U.S. Naval Air Turbine Test Station. L. G. Tilton. *Mech. Eng.*, Nov. 25–30, 1956, pp. 927–931.

Design of an Air Supply System and Test Section for Research on Scavenging Systems for Propulsion Wind Tunnels. Appendix A—**Test Section Sizing.** Appendix B—**Supersonic Section.** Appendix C—**Diffuser Ejector.** Appendix D—**Air Drying.** John G. Wilder, Kenneth Hindersinn, and Roger Weatherston. *USAF WADC TR 56-6*, May, 1956. 56 pp. 16 refs. USAF-sponsored design of an air supply system suitable for driving supersonic or transonic test sections of approximately 1 ft.² area and of a 10 by 14.4 in. supersonic and a 10 by 12 in. transonic test section.

Note on the Nilson Method of Variable Supersonic Wind Tunnel Design. M. M. Callan. *Canada, NAE LR-174*, May 15, 1956. 58 pp. Method of designing a supersonic wind tunnel by prescribing the velocity distribution along the axis from the throat to the point where the desired Mach Number is reached. From this the tunnel contour from the throat to its point of intersection with the zero characteristic is derived.

Control Valve Requirements for Gas Flow Systems. G. V. Schwent, W. K. McGregor, and D. W. Russell. *ISA J.*, Sept., 1956, pp. 323–329. Presentation of design specifications for a control valve considering such criteria as dynamic performance, resolution, leakage, drift, torque requirements, and sizing.

Balances Dards à 6 Composantes. M. Devacht. *La Recherche Aéronautique*, July-Aug., 1956, pp. 21–31. In French. Application of extensometric wire gages and of Wheatstone bridge installations to systematic analysis permitting the design of aerodynamic balances where the interactions are reduced to a small value.

Precision Planning Techniques as Applied to the Manufacture of Supersonic Wind Tunnel Models. G. W. Rawlings. *Gt. Brit., RAE TN A.D.W. 2*, Feb., 1956. 20 pp. Methods used in the construction of wind-tunnel models, taking into account that the model is designed as to external form without compromise for manufacturing convenience and that the model must conform to exacting limits of accuracy. The model types fall into three classes—airfoil research models, complete aircraft models, and guided-missile models.

Control Testing in Wind Tunnels. L. W. Bryant and H. C. Garner. *Gt. Brit., ARC R&M 2881* (Jan., 1951), 1956. 56 pp. 29 refs. BIS, New York, $2.70. Methods for the analysis and correction of wind-tunnel effects in order to permit accurate interpretation of results.

AVAILABLE

Through IAS Publications Department

Engineering Management Philosophies

A Symposium containing the four papers and discussions presented during a special session at the IAS 24th Annual Meeting, January 23–26, 1956. Fairchild Fund Paper No. **FF-14.**

Member Price, $0.50 **Nonmember Price, $1.00**

Aeronautical Reviews — BOOKS

AERODYNAMICS

The Design of Wing Sections; A Survey of Existing Knowledge on Aerofoil Design for Different Conditions. T. Nonweiler. (Aircraft Engineering Monograph; Reprinted from *Aircraft Engineering*, July, 1956.) London, Bunhill Pubns. Ltd., 1956. 28 pp., diagrs., tables. 3*s.* 6*d.*

AERONAUTICS, GENERAL

First Award Papers, 1956; IAS Student Branch Competition. New York, Minta Martin Aeronautical Student Fund, IAS, 1956. 185 pp., illus., diagrs.

Contents: Airfoil Blades Rotating on a Cylindrical Locus and Application to a Wingless-Tailless-VTOL Airplane, Franklin Chen Yueh Kun. A Method for Optimizing Two Dimensional Airfoils, Thomas A. Cincotta. The Continuous Disreefing of Parachutes, Thomas H. Clore. Investigation of an "On-Off" Type Automatic Rudder Control for Light Aircraft, Donald T. Higdon. Approximate Compressible Laminar Skin Friction with Favorable Pressure Gradients, Ely S. Levinsky. The Application of a Fast Neutron Atomic Reactor to an Unconventional Mach 3 Ramjet, Stanley Owen Smith. Some Effects of Supersonic Jet Streams Exhausted over Thin Curved Airfoils, Stanley T. Piszkin, Jr., and Charles G. Stouffer. Some Results of Linearized Transonic Flow About Slender Bodies, Hans U. Thommen. An Experimental Investigation of Transonic Base Pressures, Gerald D. Walberg. Preliminary Design Study of a Turbine Powered Executive Airplane, Richard F. Weick. Gyroscopic and Variable Center of Gravity Force. for a New Design in VTO Aircraft, Charles A. Yost.

First Award Papers, 1955; IAS Student Branch Competition. New York, Minta Martin Aeronautical Student Fund, IAS, 1955. 88 pp., illus., diagrs.

Contents: The Thin Delta Wing in Three-Dimensional Flow, Emphasizing the Effects of Boundary Layer Control and Application to the Canard Configuration, Roger L. Barron, assisted by Houston E. Landis, III. A Simple Means for Producing Efficient Wide Angle Diffusers, David L. Cochran. Effect of High Temperature on the Localized Stresses in Alloy Steel, O. Larry Gillette. Hydrofoils Applied to Sailcraft—A Problem in Aero- and Hydrodynamics, Voigt R. Hodgson. Interference Effects from Total-Pressure-Probe Rakes in Supersonic Flow, Vernon A. Lee. The Use of Nuclear Reactors for the Propulsion of Aircraft, Gene E. Maddux. Ionoprint, Airborne, High-Speed Electronic Printer, H. L. Mooney, Jr. Design and Development of an Automatic Control System for a Vertical Take-Off Model Airplane, Leroy L. Presley. A Matrix Method for Determining the Aileron Effectiveness of an Elastic Swept Wing of Arbitrary Planform and Stiffness, John Zvara.

AIR TRAFFIC CONTROL

Control Tower and Dispatcher Ratings. Charles A. Zweng. 2nd. Rev. Ed. North Hollywood, Calif., Pan American Navigation Service, 1955. 352 pp., illus., diagrs. $5.00.

The major portion of this manual is text material designed to prepare the applicant for the Aircraft Dispatcher and Control Tower Operator CAA Ratings. The book should also be of help to those interested in the position of Air Route Traffic Controller, although no certificate is issued for the position.

AIR TRANSPORTATION

The Economics of European Air Transport. Stephen Wheatcroft. Cambridge, Mass., Harvard University Press, 1956. 358 pp., diagrs., maps, tables. $6.00.

The primary purpose of this study is to examine the nature and the consequences of the present system of economic regulation of the European air transport industry. This book sets out to explain why the European air lines have fallen behind and also to suggest the conditions which are necessary for their more rapid progress. The author begins by analyzing the present economic condition of the European air-line industry. He suggests that the difficulties faced by the air lines are caused by the overextension and consequent low intensity of their operations and that it is only by high-intensity operations that the economic problems of short-haul air transport can be overcome. The problem of how to create the conditions most conducive to high-intensity operations is political as well as economic. More international planning and yet more competition between the air lines are just two of the apparently contradictory suggestions which are reconciled by the author in a Europe-wide plan for the industry. The book is in great part a result of work done by the author as a Simon Research Fellow of Manchester University beginning in 1953 when he left B.E.A. where he had participated greatly in shaping its commercial policy. At present, he is again associated with B.E.A. as Economic Planning Consultant.

Contents: *Part 1, The European Airline Industry.* (1) The Pattern of European Air Traffic. (2) The Economics of Short-Haul Air Transport. (3) Size and Efficiency in Airline Operations. (4) Seasonal Traffic Variations. (5) The European Fare Structure. (6) The Economic Consequences of Tourist Fares. (7) The Prospect of Lower Operating Costs. A Note on Cargo Services. *Part 2, Competition and Regulation.* (8) National Interests and International Regulation. (9) European Air Agreements. (10) Airline Competition and Polling Agreements. *Part 3, Requirements for Progress.* (11) Economic Planning and Regulated Competition. (12) Airline Co-operation in a Competitive Industry. (13) A Regional Organization for European Air Transport. Appendixes. Bibliography. Index.

For information on IAS Library Services, see page 101

Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

AIRCRAFT INDUSTRY

Industrial Relations in the California Aircraft Industry. Arthur P. Allen and Betty V. H. Schneider. Berkeley, Calif., Institute of Industrial Relations, University of California, 1956. 59 pp. $0.50.

The eighth in a series of short monographs on collective bargaining on the Pacific Coast. This is not an exhaustive analysis of the southern California air-frame industry but an examination of a few central themes in the bargaining relationship. The authors, both staff members of the University of California, trace the history of labor-management relations in the different periods from the infancy of the aircraft industry in 1935 to the present day when it is among our giant mass-production enterprises.

AIRPORTS

Airport Buildings and Aprons; A Reference Document of Principles and Guidance Material. Montreal, International Air Transport Association, 1956. 133 pp., diagrs. $1.50.

This document represents an attempt to satisfy the requirement for a consolidated air-line opinion and enumerates the related basic principles which should be incorporated in the design and layout of airport buildings and aprons, together with other appropriate factors and guidance information which should be taken into account. The material is presented in the form of conclusions, supporting explanation being given only in those cases where it is felt to be desirable to provide amplification.

AWARDS

Handbook of Scientific and Technical Awards in the United States and Canada, 1900–1952. Edited by Margaret A. Firth. New York, Special Libraries Association, 1956. 491 pp. $10.

CHEMISTRY

Transport Processes in Applied Chemistry; The Flow of Physical Properties in Chemical Reactors. R. C. L. Bosworth. New York, John Wiley & Sons, Inc., 1956. 387 pp., diagrs. $12.

Transport phenomena, in this work, are defined as those which are concerned with processes which take some physical entity from one point to another in an extended array of molecules. All the various transport processes—electric current, the flow of heat, mass and momentum, and certain scalar processes such as physical relaxation and chemical reaction—are given a common phenomenological description in terms of a driving force, flux, resistance, and rate of dissipation of energy. The kinetic mechanisms of all types of transport process are discussed on the basis of the types of carrier responsible for the flow. Considered also are phenomena which can arise when the same carriers operate for different flow processes or when the flow of one class of carrier gives rise to the flow of another.

A transport process that at one particular point in space gives rise to another flow process at the same or a neighboring point is said to be coupled. Conditions are derived under which it is possible to replace a whole series of coupled transport

easiest way to
GRASP
AN IDEA!
NORMA
PAT. U.S.A.
PEN
ACTUAL SIZE
Yellow or white leads also available.
You work with complex ideas. Do you "see" them quickly enough? You can with the new NORMA Pen and 3-Pencil Combination. It writes in 3 colors of pencil and as a pen . . . gives greater visual clarity . . . saves time! Guaranteed for mechanical perfection by NORMA, makers of quality Multikolor Pencils for over 25 years.
CLICK Black Pencil!
CLICK Blue Pencil!
CLICK Red Pencil!
CLICK IT'S A PEN!
The New
norma
pen and 3-pencil COMBINATION
#604—in Chrome $5.95
INTRODUCTORY Offer: Extra ink refill FREE!
ROY WALKER
If not available at your dealer, order direct from:
NORMA PENCIL CORP., Norma Bldg., Dept. AER
137 West 14th St., New York 11, N. Y.
Please send_____#604 NORMA PEN and 3-PENCIL COMBINATIONS at $5.95 each. I desire them engraved at 50c each.
NAMES FOR ENGRAVING: (please print)
_____
_____
☐ Send information on other models of NORMA —from $5.00 up
I enclose Check ☐ Money Order ☐ Amt. $_____ (If in N.Y.C. add 3% tax)
NAME_____
ADDRESS_____
CITY_____ZONE No.____STATE_____

processes by a suitably defined, single, equivalent transport process. This unified "Grand Transport Process" the author applies to the separational process, the manufacture of precision tools and fine chemicals, the operation of chemical reactors, the efficiency of factory operations, and the utilization of natural resources. The book contains a subject as well as an author index, and an extensive bibliography accompanies each chapter.

COMPUTERS

Analog Computer Techniques. Clarence L. Johnson. New York, McGraw-Hill Book Company, Inc., 1956. 264 pp., diagrs. $6.00.

As Assistant Professor, Department of Mathematics, Captain Johnson has used the material in this book for the past 2 years in the computer courses taught to advanced graduate and undergraduate students at the USAF Institute of Technology, Wright-Patterson Air Force Base. After a brief introduction to the development of the electronic analog computer, the ensuing chapters deal with The Linear Computer Components, Time-and-Amplitude-Scale Factors, The Synthesis of Servomechanism Systems, Multiplying and Resolving Servos, Additional Computer Techniques, The Representation of Nonlinear Phenomena, Multipliers and Function Generators, Miscellaneous Applications of the Electronic Analog Computer, Analog Computer Components and Computer Control, The Checking of Computer Results, Repetitive Analog Computers, and the Digital Intergrating Differential Analyzer. A background of Ohm's law, Kirchoff's laws, and a basic knowledge of differential equations is sufficient for an understanding of the majority of material presented. The book is arranged so as to permit laboratory work to accompany classroom work. A brief review of the terminology of differential equations and a brief introduction to operator notation are included in an Appendix as an aid to the less advanced reader. References are included for each chapter.

DICTIONARIES

The United States Air Force Dictionary. Edited by Woodford Agee Heflin. Air University. Washington, Superintendent of Documents, 1956. 578 pp.

This is the first attempt to analyze in detail the special vocabulary used by the Air Force in carrying out military operations. While the 16,500 entries present a broad coverage, it is assumed that the reader will search elsewhere for words not found here since the aim has been to make this a supplement to other dictionaries. Thus, terms of purely military interest are entered as are terms allied with them in the conduct of modern war—especially in the fields of aeronautics, aerodynamics, meteorology, electronics, atomic energy, supersonics, business management, and administration. Certain philosophical terms are defined, and some obsolete or historical terms are included. Abbreviations of historical interest have been listed along with those currently used. The manner of presentation is along traditional lines adapted to the particular purposes of the dictionary. Abbreviations are entered in normal alphabetical order instead of in a separate word list; phrases usually written as numerals are listed as pronounced. No attempt has been made to define a term in all its senses, only the meaning pertaining to Air Force use being given. Etymologies and pronunciations are shown only when of special interest. Cross references are numerous. The complete program of initiating, compiling, and assembling the dictionary was under the auspices of the USAF coordinated through the medium of the Research Studies Institute of the Air University.

EDUCATION

Federal Support for Science Students in Higher Education, 1954. U. S. National Science Foundation. Washington, Superintendent of Documents, 1956. 33 pp., diagrs., tables. $0.30.

ELECTRICITY

Linear Transient Analysis. Vol. 1, Lumped-Parameter Two-Terminal Networks; Vol. 2, Two-Terminal-Pair Networks, Transmission Lines. Ernst Weber. New York, John Wiley & Sons, Inc., 1954, 1956. Vol. 1, 348 pp., diagrs., tables, $7.50. Vol. 2, 452 pp., diagrs., tables, $10.50.

Professor Weber is Head, Department of Electrical Engineering, and Director, Microwave Research Institute, Polytechnic Institute of Brooklyn. His treatise has evolved from classroom notes and 20 years of teaching. The two volumes represent the subject material taught in the basic graduate course on transient analysis.

Volume 1 presents an extensive and critical review of classical and operational methods of analysis before entering upon the Laplace transform and Fourier integral methods. The six chapters present the following materials: the critical examination of the circuit concept and its relation to the electromagnetic field phenomena in terms of the underlying physical concepts and relations, a review of the classical formulation of transients in linear networks by means of integro-differential equations; analogs treated from a fundamental point of view with many illustrative examples; Heaviside's operational method with the modification given it by H. Jeffreys which permits a rigorous systematic and self-consistent development; the Laplace transform method with extensive tables of transform pairs; the frequency spectrum concept; and the transition from the discrete spectra of periodic functions to continuous spectra of nonperiodic functions, paralleling the transition from Fourier series to Fourier integrals.

Volume 2 is devoted to transient phenomena in passive and active two-terminal-pair networks, in filters, and in transmission lines. In order to make the volume self-contained, the first chapter contains a brief review of only the Fourier and Laplace transform methods. Other chapters deal with the concept and matrix description of the two-terminal-pair network; wave filters or passive fourpole lines with the mathematical discussions needed to cover the extension of the Laplace transform method to difference equations covered in the text; the application of the Fourier transform method to idealize network characteristics; a systematic exposition of active four poles; the ideal cable, because of its practical importance; and the approximations and rigorous solution for the general transmission line.

The Art and Science of Protective Relaying. C. Russell Mason. New York, John Wiley & Sons, Inc., 1956. 410 pp., diagrs. $12.

General Electric presents another treatise in its engineering series. The author is an application engineer at the Company's Engineering Planning and Development Section, Schenectady, N.Y. Much of the material has been used for several years as notes for teaching the subject in the Power Systems Engineering Course given by G-E. Some of the discussions deal with relay protection of all elements of a power system against all abnormal operating conditions; the relation of relaying to other power-system elements designing systems and applying relays to get optimum results; and the presentation of material applicable to any make of relay. No prior knowledge of protective relaying is assumed. Needed only are the fundamental principles of electrical engineering. Material has been chosen with a view toward utility, theoretical considerations being avoided as much as possible. Selective bibliographies accompany each of the 15 chapters.

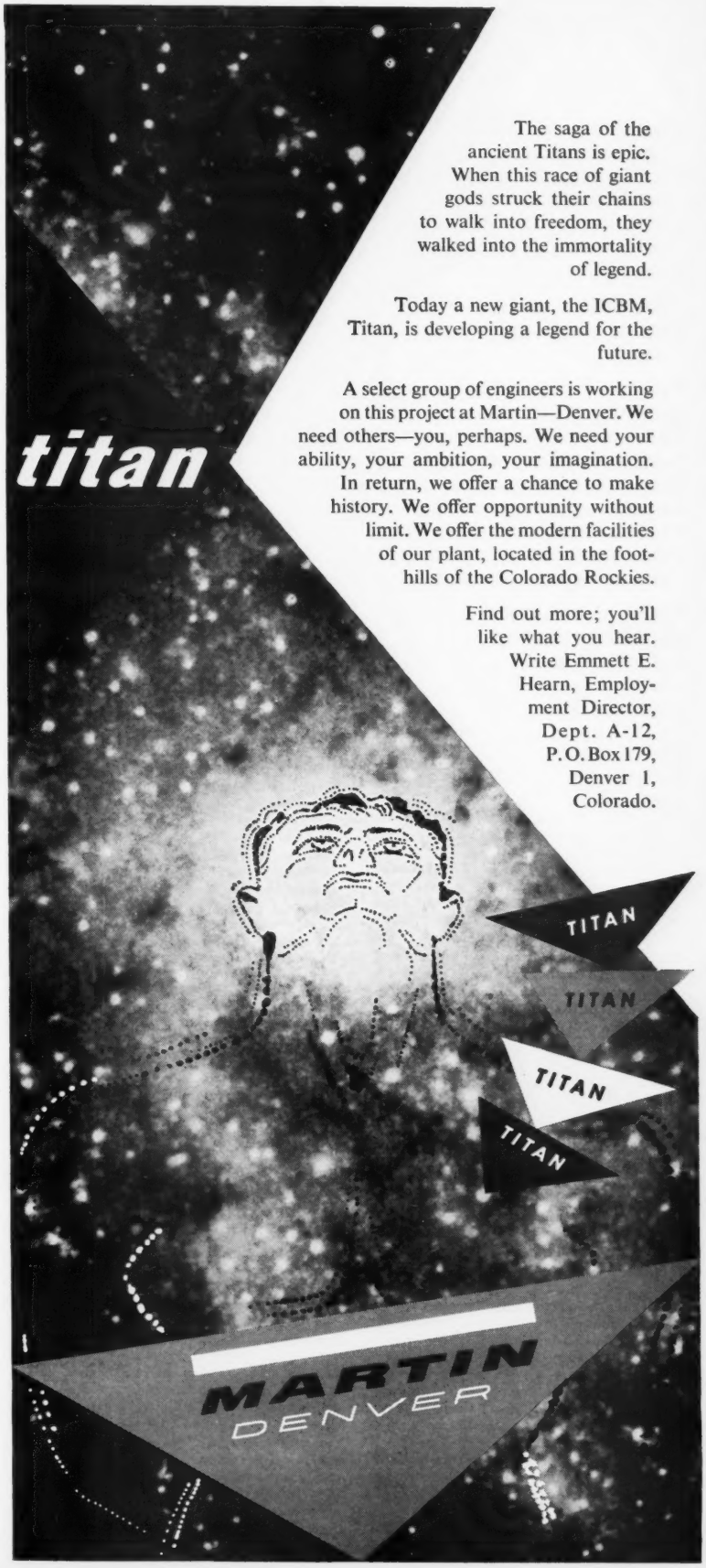
ELECTRONICS

Proceedings of the 1956 Electronic Components Symposium, Washington, May 1–3, 1956. Sponsored by American Institute of Electrical Engineers, Institute of Radio Engineers, Radio-Electronics-Television Manufacturers Association, and West Coast Electronic Manufacturers Association. New York, Engineering Publishers, 1956. 240 pp., illus., diagrs., tables. Cloth, $8.25; Paper, $5.00.

Contents: Future Demands on Component Design, W. I. Bull. A Broad Survey of the Military Electronic Equipment Reliability Problem and its Controlling Factors, Chester I. Soucy. A Review of Recent British Component Developments, C. E. Richards. Looking Forward into the Future, Karl Martinez. More or Better Engineers in Components, J. D. Ryder. New Glasses and Electrical Components Applications, W. E. Hauth and A. L. Pugh, Jr. Positive Temperature Coefficient of Resistance Thermistor Materials for Electronic Applications, H. A. Sauer and S. S. Flaschen. Ferrites for Use in S-Band Microwave Components, H. C. Rothenberg. Properties of Piezoelectric Titanates and Zirconates, Including a Discussion on Their Control and Evaluation, T. G. Kinsley and R. D. Wehrle. Glass in High Temperature Components, Henry S. Craumer. Standards for Capacitor Paper, H. A. Anderson. Factors Affecting Back Swing of High Power Pulse Transformers, Trevor Temple. D.C. Current Amplification Factor of Junction Transistors, Chaang Huang and A. Anouchi. The Use of Dispersion Measurements for Analyzing Ceramic Components, D. A. Lupfer. Examination of Contact and Other Surfaces by a Plastic Replica Technique, H. W. Hermance and T. F. Egan. Miniature Strip Transmission Line and Transmission Line Components, E. N. Torgow and J. W. E. Griemsmann. The Effects of Nuclear Radiation on Electronic Components, C. C. Robinson. Automatic Testing of Components, F. M. Booth. A Dielectrometer for Millimeter Wavelengths, M. J. Ehrlich. Quality Control of Magnetic Sub-Assemblies, Norton Cushman. High Frequency Transistor Test Set, C. E. Williams. An Automatic Card Punching Transistor Test Set, M. L. Embree and D. E. Williams. Magnettor Probe for Traveling Wave Tube Magnetic Field, V. E. Legg and G. N. Packard. A Report on the State of the Art of Semiconductor Devices, D. B. Kret. High Power Silicon Transistors, John S. Saby. Theory of Operation and Application of a New Series of Fixed and Adjustable Corona Discharge Voltage Regulator Tubes, N. Anton and M. Youdin. The Application of Industrial X-Ray Techniques for the Prevention of Reliable Tube Defects, E. A. Kolm. Current Trends in Cathode Ray Tube Development and Design, B. H. Rosen. Manufacturing Subminiature Tubes to Meet MIL-E-1B Microscopic Inspection, R. E. Brooks. Metal Film Power Resistors, J. J. Bohrer, W. E. Hauth, Jr., and S. J. Stein. Precision and High Temperature Metal Film Resistors, S. J. Stein and J. Riseman. Wafer Coils for Traveling Wave Tube Solenoids, A. S. Gutman, A. Babcock, and Z. Zack. Pyrolytic Alloy High Temperature Resistors, C. Wellard and K. Gentner. New Type Miniaturized Power Transformers for High Temperature Airborne Applications, H. S. Feder and A. B. Haines. A New Thermally Fused Metal-to-Ceramic Volume Resistor, R. C. Langford and J. Ruckelshaus. High Q Resonant Charging Reactors for Magnetic Radar Pulsers, C. E. Carter, Jr. Ceramic Transformers and Filters, C. A. Rosen. Distributed Components in Printed Circuits, A. Smith and G. Cooper. A New Type of Ferroelectric Shift Register, J. R. Anderson. Recent Progress in the Development of Standard Functional Divisions for Electronic Equipment, J. Reeves and R. S. Shultz. A Systematic Plan for Predicting Equipment Reliability, J. A. Connor. Reliability Theory and Vital Engineering Interpretations, H. L. Weurffel.

Electronics' Engineering Manual, Vol. 7. New York, *Electronics*, McGraw-Hill Publishing Company, Inc., 1956. 252 pp., illus., diagrs. $2.00.

A collection of feature articles from the monthly issues of *Electronics*. The articles, written by engineers in the field, have been chosen to provide material of broad practical value. The book provides a ready source for reading about current designs and techniques and serves as a reference when circuits and data are needed. The 76 articles are grouped under the following aspects: sound, industrial applications, measurement, receivers, broadcasting, and design and research.


titan
The saga of the ancient Titans is epic. When this race of giant gods struck their chains to walk into freedom, they walked into the immortality of legend.
Today a new giant, the ICBM, Titan, is developing a legend for the future.
A select group of engineers is working on this project at Martin—Denver. We need others—you, perhaps. We need your ability, your ambition, your imagination. In return, we offer a chance to make history. We offer opportunity without limit. We offer the modern facilities of our plant, located in the foothills of the Colorado Rockies.
Find out more; you'll like what you hear. Write Emmett E. Hearn, Employment Director, Dept. A-12, P.O. Box 179, Denver 1, Colorado.
TITAN
TITAN
TITAN
TITAN
MARTIN
DENVER

FUELS & LUBRICANTS

ASTM Manual for Rating Motor Fuels by Motor and Research Methods; 1956. Philadelphia, American Society for Testing Materials, 1956. 180 pp., illus., diagrs., tables. $6.75.

The purpose of this Manual has been to revise and make current ASTM Standards D 357 and D 908 and to present six appendixes which, with text and illustrations, provide factual information and data on the operation and maintenance of the knock testing equipment. The appendixes, which contain information for conducting standardized octave ratings on motor fuels, are: (1) Apparatus, (2) Reference Materials and Blending Accessories, (3) Operation, (4) Maintenance, (5) Installation and Assembly, and (6) Building and Utility Requirements.

INSTRUMENTS

Application of Spring Strips to Instrument Design. Gt. Brit., National Physical Laboratory, Department of Scientific and Industrial Research. (Notes on Applied Science, No. 15.) London, H.M.S.O.; New York, British Information Services, 1956. 25 pp., illus., diagrs. 2s., $0.36.

Here's How: Operation of the MH-11CA Autopilot for the B-66 Tactical Bomber. Minneapolis, Aeronautical Division, Minneapolis-Honeywell Regulator Company, 1956. 16 pp., illus., diagrs.

MATERIALS

Molybdenum. L. Northcott. London, Butterworths Scientific Publications; New York, Academic Press, Inc., 1956. 222 pp., illus., diagrs., tables. $6.80.

This book is the fifth of a series, each written by an authority in his subject and dealing with the metallurgy and properties of the rarer metals. As a textbook and readable reference source, it provides the background and the metallurgical, chemical, and physical data of the metal concerned.

Contents: (1) History, Occurrence and Uses of Molybdenum. (2) Extraction of Molybdenum. (3) Physical Properties of Molybdenum. (4) Powder Metallurgy, Arc Melting, Fabrication. (5) Mechanical Properties of Molybdenum. (6) Mechanical Properties of Molbydenum Alloys. (7) Alloys of Molybdenum. (8) The Oxidation and Protection of Molybdenum. (9) The Joining of Molybdenum. Subject Index.

Abstracts: Symposium on the Technology of Molybdenum and its Alloys; Detroit, Sept. 18–19, 1956, Sponsored by Office of Naval Research. (ONR Symposium Report ACR-12.) Washington, U.S. Office of Naval Research, 1956. 20 pp.

Symposium on Impact Testing; Presented at the 58th Annual Meeting, ASTM, Atlantic City, N.J., June 27, 1955. (ASTM Special Technical Publication No. 176.) Philadelphia, American Society For Testing Materials, 1956. 170 pp., illus., diagrs., tables. $3.50.

Contents: Notched-Bar Testing-Theory and Practice, S. L. Hoyt. Transition Behavior in V-Notch Charpy Slow-Bend Tests, Carl E. Hartbower. Effects of Manganese and Aluminum Contents on Transition Temperature of Normalized Carbon-Manganese Steel, T. N. Armstrong and O. O. Miller. Low-Temperature Transition of Normalized Carbon-Manganese Steels, T. N. Armstrong and W. L. Warner. Effect of Specimen Width on the Notched Bar Impact Properties of Quenched-and-Tempered and Normalized Steels, R. S. Zeno. Reproducibility of Charpy Impact Test, David E. Driscoll. Automatic Impact Testing from Room Temperature to −236 C, Thomas S. DeSisto. The Influence of Pendulum Flexibilities on Impact Energy Measurements, Joseph I. Bluhm. The Impact Tube: A New Experimental Technique for Applying Impulse Loads, George Gerard. Longitudinal Impact Test of Long Bars with a Slingshot Machine, W. Ramberg and L. K. Irwin. Stress-Strain Relationships in Yarns Subjected to Rapid Impact Loading, Herbert F. Schiefer, Jack C. Smith, Frank L. McCrackin, and W. K. Stone. Shock Tester for Shipping Containers, W. H. Cross and Max McWhirter. Shock Testing with the Rocket-Powered Pendulum, R. W. Hager. Properties of Concrete at High Rates of Loading, D. Watstein.

Latex, Natural and Synthetic. Philip G. Cook. New York, Reinhold Publishing Corporation, 1956. 231 pp., diagrs., tables. $3.50.

Shows how both natural and synthetic types of rubber latex are produced, modified, and finally converted into useful products. The book is for the newcomer to the field and for the student of industrial chemistry in general. The author is Technical Superintendent, General Latex and Chemical Corporation.

Handbook of New Engineering Materials. Prepared by the Editors of *Materials & Methods*. New York, *Materials & Methods*, 1956. 310 pp., illus., diagrs,, tables. $1.00.

Contents: Titanium. The Silicones. How and Where to Use the Newest Plastics (Rigid Polyvinyl Chloride Plastics, Glass Reinforced Plastics, The Thermoplastics). Wrought Aluminum Alloys for Specialized Needs. Applications of Special Purpose Metals (Titanium, Zirconium, Molybdenum, Tungsten, Tantalum, Columbium Vanadium, Hafnium). Materials for High Temperature Service. Age Hardenable Metals as New Alloys. How to Select Aluminum Bronze. Engineering Uses of Ceramics, Glass, and Rubber. Properties and Applications of Die Castings. New Uses for Carbon and Graphite Materials and Parts. Selecting Engineering Materials to Reduce Costs (135 Case Histories). How Engineering Materials Can Improve Quality (79 Case Histories).

MATHEMATICS

Contributions to the Theory of Nonlinear Oscillations, Vol. 3. Edited by S. Lefschetz. Princeton, N.J., Princeton University Press, 1956. 285 pp., diagrs. $4.00.

Contents: A Rotated Vector Approach to the Problem of Stability of Solutions of Pendulum-Type Equations, George Seifert. Asymptotically Autonomous Differential Systems, L. Markus. Nonlinear Differential Equations Systems, Edmund Pinney. On a Nonlinear Differential Equation Containing a Small Parameter, Violet B. Haas. Critical Points at Infinity and Forced Oscillation, Ralph E. Gomory. On Certain Critical Points of a Differential System in the Plane, Samuel Barocio. On the Total Number of Singular Points and Limit Cycles of a Differential Equation, Felix Haas. Banach Spaces and the Perturbation of Ordinary Differential Equations, George Hufford. A Fixed Point Theorem, Walter T. Kyner. Perturbation Theorems for Nonlinear Ordinary Differential Equations, S. P. Diliberto and G. Hufford. A Note on the Existence of Periodic Solutions of Differential Equations, S. P. Diliberto and M. D. Marcus. An Invariant Surface Theorem for a Nondegenerate System, M. D. Marcus. An Application of Periodic Surfaces (Solution of a Small Divisor Problem), S. P. Diliberto. Repeating Solutions for a Degenerate System, M. D. Marcus. Bounds for Periods of Periodic Solutions, S. P. Diliberto. One-Dimensional Repeating Curves in the Nondegenerate Case, Paul Koosis.

Engineering Analysis; A Survey of Numerical Procedures. Stephen H. Crandall. New York, McGraw-Hill Book Company, Inc., 1956. 417 pp., diagrs., tables. $9.50.

A text dealing with the analysis of complex engineering problems and the methods for organizing practical programs for their numerical solution. Engineering analysis as used in this book signifies (1) the construction of a mathematical model for a physical situation and (2) the reduction of the mathematical problem to a numerical procedure. Though many examples are given of the first step, concentration is centered upon the second. Material is arranged according to the types of problem dealt with: equilibrium, eigenvalue, and propagation. The first three chapters are concerned with discrete or lumped-parameter systems, while the last three deal with continuous systems. Procedures suitable for hand computation and for automatic machine computation are covered, including iteration, relaxation, perturbation, and variational and finite difference methods. Evolved from a series of lectures, the book is intended for the engineer or engineering mathematician and assumes the mathematical knowledge of an engineering graduate student. The author, Associate Professor of Mechanical Engineering, M.I.T., develops three items which are not usually included in engineering mathematics courses: matrix notation, calculus of variations, and the theory of characteristics of partial differential equations. The text contains some 432 exercises with answers to most of them, a brief bibliography, and a subject index.

The World of Mathematics: A Small Library of the Literature from A'h-mose the Scribe to Albert Einstein, Presented with Commentaries and Notes by James R. Newman, Editor. New York, Simon & Schuster, Inc., 1956. 2,535 pp. 1,000 drawings, halftones, diagrams, and facsimiles. Four volumes, $20 the set.

Some 15 years in the making, this massive anthology of technical and scholarly writings on the nature, uses, and history of mathematics contains over 1,000,000 words and is presented with 130,000 words of biographical and explanatory comment by the editor. The editor is a member of the Board of Editors of *Scientific American* magazine. Every field of mathematical thought is represented in these four volumes which include two full-length books and more than 100 essays, articles, and stories wherein the thoughts of leading mathematicians, the varying state of the art, and its numerous applications in the physical world are explored from ancient times to the present.

As an introduction to his subject, Mr. Newman has chosen P. E. B. Jourdain's primer, "The Nature of Mathematics," which discusses concepts widely used but not always comprehended by the mathematician, and Herbert Westren Turnbull's "The Great Mathematicians," a biographical history which provides a setting for the material to follow and serves as a small reference manual for the general reader. Shorter selections treat the accomplishments of such outstanding figures as Euclid and Eratosthenes among the Greeks. Kepler, the mathematician of the sky, is represented by his laws of planetary motion; Descartes by his thoughts on geometry. The giants, Archimedes, Newton, and Gauss, are revealed in their formative years and at the height of their powers, while the contributions of Russell and Whitehead also appear as representative of more modern times.

The mathematics of space and motion and of the physical world is presented in the writings of Galileo, Helmholtz, and others. There are essays on the mathematics of heredity, psychology, money, astronomy, and the social sciences. Mathematics as employed in automata processes and in warfare is discussed along with its gentler aspects in literature, music, and art. The laws of chance and their numerous applications in the realm of probability and statistical procedure are also included in contributions by Laplace, Peirce, and Keynes. Interspersed among the more serious works are satirical essays aimed at divesting mathematics of some of its grimness. Certain other selections are devoted to the pleasures of mathematical logic and, conversely, the pain of unreasonable numbers.

Integral Functions. M. L. Cartwright. (Cambridge Tracts in Mathematics and Mathematical Physics, No. 44.) Cambridge, England, University Press; New York, Cambridge University Press, 1956. 135 pp. $3.15.

In the theory of integral functions, primarily those parts which concern the behavior of a function of finite order in an angle are made more easily available. The author is Mistress of Girton College, Cambridge, and Lecturer in Mathematics at the University of Cambridge.

Contents: Preliminary Results. Integral Functions of Finite Order. The Phragmén-Lindelöf Principle. The Proximate Order of an Integral Function. Iutegral Functions, Type Results. Some Results for Angles. Lines of

Julia. Singularities of Power Series and $h(\theta)$. Bibliography. Index.

MISSILES

Aerodynamics; Propulsion; Structures and Design Practice. E. Arthur Bonney, Maurice J. Zucrow, and Carl W. Besserer. (Principles of Guided Missile Design. Grayson Merrill, Editor.) Princeton, N.J., D. Van Nostrand Company, Inc., 1956. 595 pp., illus., diagr., tables. $10.

This is the second volume in a series prepared for graduate students, professional engineers, and technical officers of the Armed Services who are engaged in guided-missile design and operation. The material, which is divided into three sections, was written by specialists in their fields under the overall guidance of Captain Merrill, Technical Director of the Jupiter Ballistic Missile Project in the Navy's Bureau of Ordnance.

The section on Aerodynamics was written by E. A. Bonney, Chief of Aerodynamics, Applied Physics Laboratory, The Johns Hopkins University. The problems taken up are peculiar to missiles in the supersonic range: the effect of atmospheric conditions on maneuverability; the lift, moment, and drag forces created in flight by various configurations; and the influence of aeroelasticity on divergence, flutter, and vibration. Coverage is limited to external aerodynamics only; internal flow considerations are examined in the section on propulsion. The three principal techniques for obtaining aerodynamic data—wind tunnels, ballistic ranges, and flight tests—are discussed, as well as the aerodynamic aspects of launching and booster configurations.

The Propulsion section was written by M. J. Zucrow, Professor of Gas Turbines and Jet Propulsion, Purdue University, and treats the fundamental thermodynamic and aerodynamic principles of thermal jet and rocket engines as applied to guided missiles. A comparison is made of their operating characteristics and performance, particularly in the flight regime. The major research problems pertinent to further development are enumerated. Some attention is given to the basic momentum and reaction principles applied to propulsion, and a description of the theory of gas dynamics is included. Propellants and fuels for rocket engines are described in detail, and the principle of stepped rockets is explained.

Structures and Design Practice was written by C. W. Besserer, Systems Engineer, Technical Staff, The Ramo-Wooldridge Corporation, and concerns itself with actual missile structures and techniques of packaging components. Structural design criteria, environmental conditions, reliability concepts and philosophies, packaging engineering, and a general integration of missile design fields are covered here. The section closes with a discussion on design practice, system interactions, and cost estimating for a missile development or production program.

The authors have supplied extensive bibliographies containing references to papers, articles, books, and reports, all of which were chosen for their applied engineering content as related to their particular areas of study.

PERSONNEL

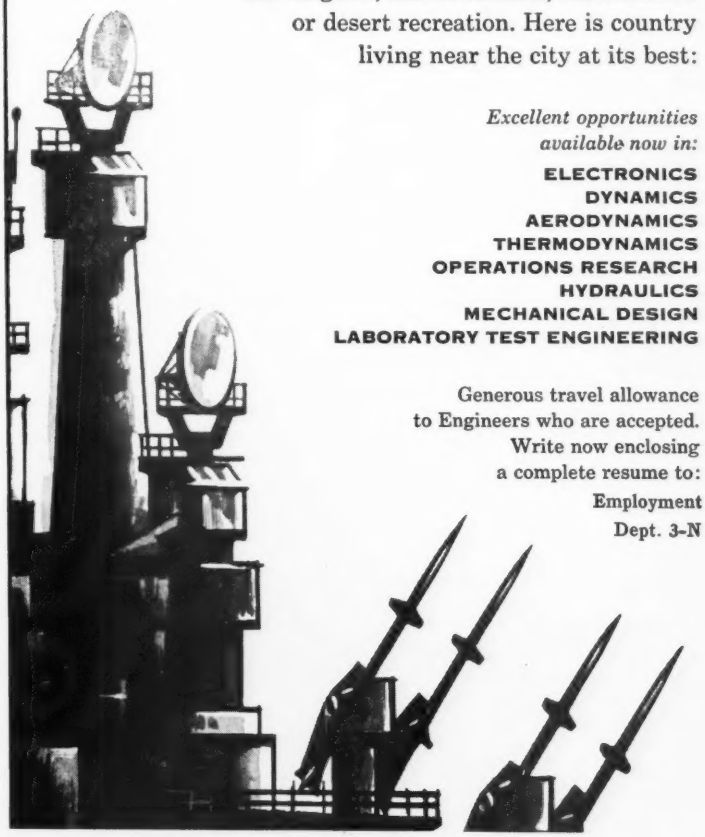
The National Committee for the Development of Scientists and Engineers; Together with a Staff Statement of the Problem and Some Suggested Solutions. Washington, National Science Foundation, May, 1956. 11 pp.

Supervision of Scientific and Engineering Personnel. Compiled by John T. Lloyd and Robert D. Gray. (Bulletin No. 26.) Pasadena, Calif., Industrial Relations Section, California Institute of Technology, 1956. 82 pp. $8.75.

Material for this bulletin was derived from a number of conferences and meetings sponsored in 1953–1956 by the Industrial Relations Section, California Institute of Technology. The text is in outline form and itemizes the problems encountered in the various aspects of employer-employee relations and provides suggested solutions.

ENGINEERING UNLIMITED

...an established concept at Convair-Pomona where your opportunities in the career of your choice are virtually unlimited. Work in the finest engineering facility in the country at America's first exclusive Guided Missile plant. Ultra-modern surroundings, completely air-conditioned, in beautiful Pomona only minutes from Los Angeles, the mountains, the seashore or desert recreation. Here is country living near the city at its best:



Excellent opportunities available now in:

ELECTRONICS
DYNAMICS
AERODYNAMICS
THERMODYNAMICS
OPERATIONS RESEARCH
HYDRAULICS
MECHANICAL DESIGN
LABORATORY TEST ENGINEERING

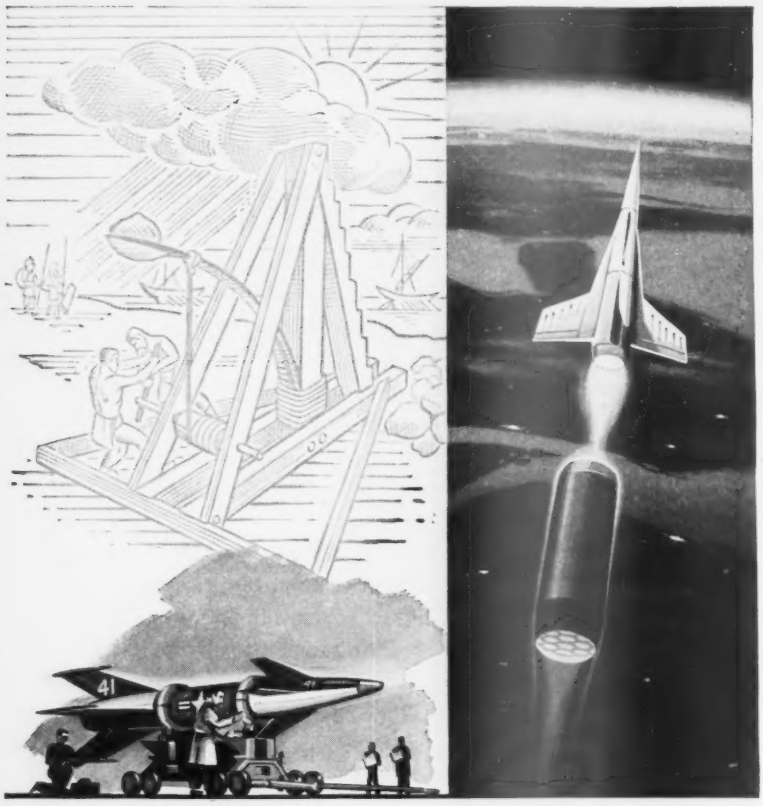
Generous travel allowance to Engineers who are accepted. Write now enclosing a complete resume to:

Employment
Dept. 3-N

C-V CONVAIR

CONVAIR
A DIVISION OF
GENERAL DYNAMICS
CORPORATION
POMONA
CALIFORNIA

GD GENERAL DYNAMICS



ONE OF A SERIES — depicting missiles — "Yesterday, Today and Tomorrow"

Συστήματα Όπλων

. . . in Greek means *weapons systems;* and, with the catapult, the Greeks developed one of the earliest weapons systems. Perfected slowly, it reached the height of its effectiveness during the Middle Ages. Today's weapons systems concepts are tremendously more complex than the ancient catapult. The swift advances of science enables only the highly integrated engineering teams to keep pace with the changes. Combined with a perceptive management policy, such a team in a relatively short time can achieve a goal that once took centuries.

At Bell there is both progressive management and creative engineering teams. With that years-ahead look, Bell is concerned not only with today's problems but with tomorrow's successes. Backed by years of successful missile development and management, Bell is now engaged in new projects in advanced missile design. To the creative engineer desiring top assignments, this is an opportunity to work on a *completely new weapons system.* For qualified engineers with a B.S. or advanced degree, Bell is offering positions where a high level of professional achievement may be attained.

AERODYNAMICS
STRUCTURES
HEAT TRANSFER
THERMODYNAMICS
VIBRATION AND FLUTTER ANALYSIS

Dept. B
Contact: Manager, Engineering Personnel

BELL Aircraft CORPORATION

P. O. Box 1 Buffalo 5, N. Y.

PHOTOGRAPHY

Microrecording; Industrial and Library Applications. Chester M. Lewis and William H. Offenhauser, Jr. New York, Interscience Publishers, Inc., 1956. 456 pp., illus., diagrs., tables $8.50.

PHYSICS

Spectroscopy at Radio and Microwave Frequencies. D. J. E. Ingram. New York, Philosophical Library, 1956. 332 pp., illus., diagrs., tables. $15.

A broad approach has been taken by the author who is Lecturer and Research Fellow, University of Southampton, England. The book should be of interest to many research workers and students seeking a general picture of the methods and applications of this branch of spectroscopy. Detailed information is also provided for guidance in the design of experimental apparatus and equipment.

Content: (1) Introduction. (2) The Production and Detection of Microwaves. (3) Waveguide Techniques. (4) Microwave Spectroscopes. (5) Results and Theory of Gaseous Spectroscopy. (6) Results and Theory of Paramagnetic Resonance. (7) Ferromagnetic Resonance. Free Radicals and F-Centres. (8) Radiofrequency Spectroscopy. (9) Applications of Radiofrequency and Microwave Spectroscopy. Appendix. Author Index. Subject Index.

PILOTING

Radio and Instrument Flying; A Guide to the Instrument Rating. Charles A. Zweng and Allan C. Zweng. 14th. Rev. Ed. North Hollywood, Calif., Pan American Navigation Service, 1956. 299 pp., illus., diagrs., tables. $5.00.

Revisions in this edition reflect changes in aeronautical charts, the establishment of VHF radio ranges, radio aids, computation of speeds in knots, methods of weather reporting, etc.

POWER PLANTS

Performance Criteria of Gas-Turbine Combustion Chambers; A Method of Comparison and Selection for the Designer. D. B. Spalding. (Aircraft Engineering Monograph; Reprinted from *Aircraft Engineering,* April, May, 1956.) London, Bunhill Pubns. Ltd., 1956. 37 pp., diagrs. 4*s*.

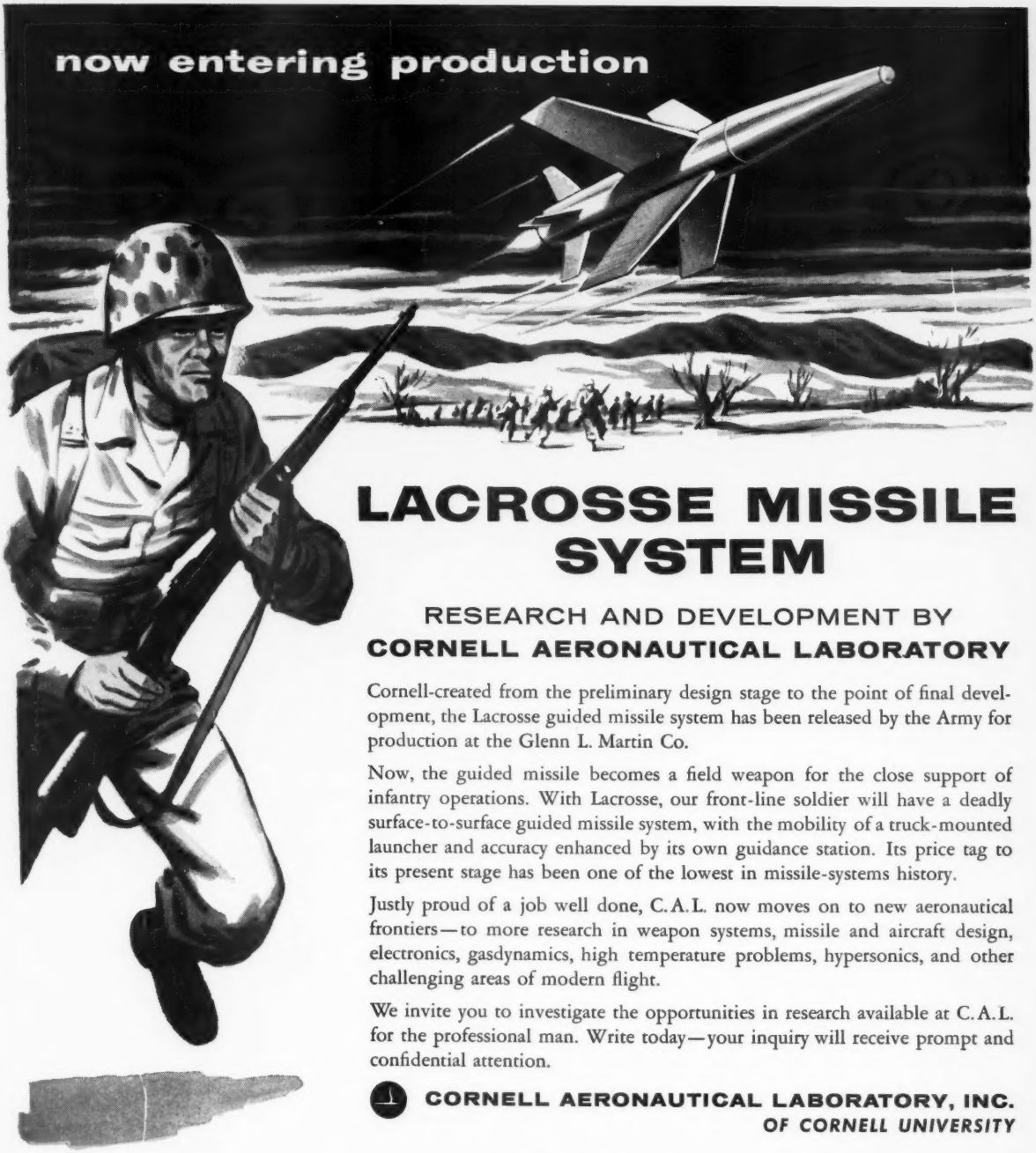
PRODUCTION

Engineering Inspection, Measurement and Testing. H. C. Town and R. Colebourne. New York, Philosophical Library, 1956. 191 pp., illus., diagrs., tables. $8.75.

This presentation on the current status of metrology is intended for the student and for the engineer engaged in precision measurement and inspection. The function of the modern factory inspection department is explained, and a brief history is given of the development of standards and measurement methods. Other chapters deal with the principles and practice of precision measurement and with comparators and other measuring and inspection machines. Attention is given to measurement during machining and automatic sizing operations and to screw-thread measurement. The work concludes with an exposition of the measurement of surface finish. Examples are drawn mostly from British practice.

Induction Heating Practice; A Handbook on the High Frequency Induction Process for All Concerned With Engineering Production. D. Warburton-Brown. New York, Philosophical Library, 1956. 191 pp., illus., diagrs., tables. $10.

Brazing, soldering, hardening, annealing, tempering, and similar operations performed through controlled heat form the basis for discussion in this work by a British expert. Assuming the interest of production engineers, foremen, and operators of induction heating equipment to be in the operational aspects of the subject, the author has emphasized the practical elements. Since the selection of equipment will



LACROSSE MISSILE SYSTEM

RESEARCH AND DEVELOPMENT BY CORNELL AERONAUTICAL LABORATORY

Cornell-created from the preliminary design stage to the point of final development, the Lacrosse guided missile system has been released by the Army for production at the Glenn L. Martin Co.

Now, the guided missile becomes a field weapon for the close support of infantry operations. With Lacrosse, our front-line soldier will have a deadly surface-to-surface guided missile system, with the mobility of a truck-mounted launcher and accuracy enhanced by its own guidance station. Its price tag to its present stage has been one of the lowest in missile-systems history.

Justly proud of a job well done, C.A.L. now moves on to new aeronautical frontiers—to more research in weapon systems, missile and aircraft design, electronics, gasdynamics, high temperature problems, hypersonics, and other challenging areas of modern flight.

We invite you to investigate the opportunities in research available at C.A.L. for the professional man. Write today—your inquiry will receive prompt and confidential attention.

CORNELL AERONAUTICAL LABORATORY, INC.
OF CORNELL UNIVERSITY

WRITE FOR FREE REPORT

The story behind Cornell Aeronautical Laboratory and its contributions to aeronautical progress is vividly told in a 68-page report, "A Decade of Research." Whether you are interested in C.A.L. as a place to work or as a place to watch, you will find "A Decade of Research" both useful and pertinent. Mail in the coupon now for your free copy

W. A. DIEFENBACH
CORNELL AERONAUTICAL LABORATORY, INC.
Buffalo 21, New York

Please send me a copy of "A Decade of Research."

Name

Street

City Zone State

☐ Please include employment information.

be influenced by that which is available commercially, examples are given to provide an indication of the type of work which can be undertaken with generators of different power outputs. The book further discusses jigs or handling equipment, the design of work-coils and inductors, and the modification of the design of components or assemblies to facilitate use of the process. Various applications of high-frequency induction heating are given from the motor and motor accessory industries to electrical components and precision instruments. One chapter is devoted to the special problems of gear hardening.

SAFETY

General Aviation Accidents (Non-Air Carrier), a Statistical Analysis; Calendar Year 1955. U.S. Civil Aeronautics Administration. Washington, U.S. Department of Commerce, 1956. 16 pp., tables. $0.25.

SPACE TRAVEL

Satellite. Erik Bergaust and William Beller. Garden City, N.Y., Hanover House, 1956. 287 pp., diagrs. $3.95.

Project Vanguard will culminate with the launching of earth-circling satellites during the International Geophysical Year (IGY). The authors have compiled and interpreted news releases and technical reports on the subject to present a popular treatment of the project. In the discussions of costs, time elements, size, and the problems of materials, equipment, and launching, we are also presented with a picture of rocket science at today's stage of development. Further discussions and conjectures concern the possibilities attendant upon a successful conclusion of the project, new data to be gained from the atmosphere, the results from better weather forecasting, and the further exploration of the moon, sun, and planets. The authors are, respectively, Rocket and Missile Editor, *American Aviation*, and Managing Editor, *Aero Digest*.

STRUCTURES

Bibliography on Residual Stress. T. C. Huang. An Extension and Editorial Revision of a Residual Stress Survey Made by A. J. Durelli and R. H. Jacobson of the Armour Research Foundation for the International Harvester Company. New York, Society of Automotive Engineers, Inc., 1954. 196 pp. $10.

For the scientist and engineer concerned with residual stress as it affects the quality and cost of industrial parts, a list containing 1,545 entries on the subject has been assembled from both foreign and domestic literature. Sources used in the compilation are included as the appendix. The bibliography itself consists of three sections. Part 1 contains the references arranged alphabetically by author, accompanied by an abstract or comment. Part 2 has all the material listed under the following five subject subdivisions: measurement of residual stresses; occurrence of residual stress; origin, control, and removal of residual stresses; effect of residual stresses; and miscellaneous. Part 3 consists of an author index wherein the second and third authors of an article are listed. The method of expediting cross reference from the coauthor and subject indexes has been accomplished by assigning a serial code number to each entry in Part 1.

THERMODYNAMICS

Properties of Combustion Gases: System C_nH_{2n}-Air. Vol. 1, Thermodynamic Properties; Vol. 2, Chemical Composition of Equilibrium Mixtures. Aircraft Gas Turbine Development Department, General Electric Company. Edited by H. N. Powell and S. N. Suciu. New York, McGraw-Hill Book Company, Inc., 1955. Vol. 1, 377 pp., tables; Vol. 2, 677 pp. $75, the set.

Comprised wholly of tables with brief introductory text, these volumes provide an accurate knowledge of the thermodynamic properties and behavior of the working fluid of the air-breathing combustion engine under very wide ranges of operating conditions. The tables are applicable to the combustion gases of any hydrocarbon fuel with a hydrogen-to-carbon-atom ratio of two, independently of the fuel's chemical make-up or heating value. This ratio is typical for a wide variety of gasoline and kerosene type of fuels. The books are intended to be of value to those engaged in combustion research, in the development of gas turbines and turbojet engines, and in aircraft and missile propulsion studies and also to chemical companies engaged in the high-temperature syntheses from combustion-type reactors.

Volume 1, *Thermodynamic Properties*, contains 45 pages of introductory material and lists in English units the following functions: enthalpy, entropy, mean molecular weight, density, sonic velocity (on both equilibrium and frozen composition bases), heat capacity, and two nonideality coefficients. The independent variable grid is: temperature from 600° to 5,000°R. in 100°R. increments; pressure from 0.01 to 30 atmospheres in 22 increments on a quasilogarithmic scale; equivalence ratio from 0.25 to 4.0 in 15 increments, approximately adjusted to the degree of nonideality. The primary source data for both volumes are taken from the National Bureau of Standards–American Petroleum Institute publications.

Volume 2, *Chemical Composition of Equilibrium Mixtures*, lists the equilibrium chemical composition of the combustion gases in terms of the molfractions for temperatures above 2,500°R. on the same grid of independent variables which is used in Volume 1. The following species are considered: A, C_s (graphite), CO, CO_2, H_2O, O_2, W_2, H, O, N, NO, OH, CH_4 and NH_3. All molfractions greater than 10^{-9} are listed. In addition, Volume 2 contains tabulations of the enthalpy, Gibbs free energy, entropy, and heat capacity functions of the above pure species in 100°R. increments in the range 600° to 5,000°R.

The tabulated enthalpies are defined in a way which permits mixtures of all fuel/air ratios, burned as well as unburned, to be treated on a continuous and consistent basis without reference state corrections. With a minor correction, the enthalpies are consistent with the Keenan and Kaye "Gas Table" values for pure air (not with their combustion gas values). All computations for *Properties of Combustion Gases*, beginning with the interpolations on the original source data, were made with an IBM Electronic Computer. Procedures are developed for applying the tabulated data to a number of frequently encountered engineering problems: determination of adiabatic flame temperatures, theoretical heat releases, combustion in a constant-area duct, and isentropic expansions (on both equilibrium and "frozen" composition bases). Several problems and their numerical solutions are included to illustrate these methods. The choice of the functions which are tabulated is keyed to the needs of the most general thermodynamic relations which are valid with or without chemical dissociation and other deviations from ideal behavior. Although the tables are primarily aimed at providing basic information for gas-turbine engineering, especially cycle calculations, the data are pertinent and applicable to many general areas—e.g., dynamics of compressible flow and fundamental combustion research. Explanation of tables, notes on interpolation, applications, sources, symbols, and definitions are given in the introductions to both volumes.

Contributing to the project were H. N. Powell and S. N. Suciu of G-E, who organized and reviewed the tables and prepared all textual material; S. R. Brinkley, Jr., of Combustions and Explosives Research, Inc., who wrote the high-temperature calculation program (for computing the equilibrium compositions and the gross mixture properties); H. E. Edwards of G-E, who was responsible for the writing and all machine operations of the low-temperature calculation program; and H. A. Fremont of G-E, who administered the combustion gas property evaluation project.

Selected Combustion Problems, II: Transport Phenomena; Ignition; Altitude Behaviour and Scaling of Aeroengines. Combustion Colloquium, Liège, Belgium, December 5–9, 1955. NATO, Advisory Group for Aeronautical Research and Development (AGARD). London Butterworths Scientific Publications; New York, Interscience Publishers, Inc., 1956. 495 pp., illus., diagrs., tables. 90*s*., $12.50.

The 18 papers of this colloquium are in either English or French and have individual bibliographies. The articles are assigned to five aspects of combustion problems: aircraft engines and fuels; ignition and flammability; transport properties; high altitude combustion problems; and similarity, scaling, and fundamental parameters in combustion. Each of the five sections concludes with a group discussion of the problems presented and authors' replies to questions posed or suggestions made. Concluding the volume are descriptions of the motion-picture films presented during the Colloquium and a subject index.

Contents: Les Performances des Moteurs d'Avions, A. Capette. Fuels for Turbojet Powered Aircraft, R. R. Hibbard and H. C. Barnett. Fundamental Principles of Flammability and Ignition, B. Lewis and G. von Elbe. The Ignition of Flowing Gases, L. D. Wigg. Inflammation et Allumage dans les Moteurs-Fusées à Propergols Liquides, M. Barrère and A. Moutet. Thermal Ignition, with Particular Reference to High Temperatures, R. S. Brokaw. Fundamental Equations in Aerothermochemistry, Th. von Kármán. Quelques Considérations sur la Convection de la Chaleur aux Grandes Vitesses et aux Temperatures Elevées, E. A. Brun. Sources of Transport Coefficients and Correlations of Thermodynamic and Transport Data, F. Hilsenrath. Combustion en Altitude dans les Turbo-Réacteurs, F. Soissons. The Influence of Altitude Operating Conditions on Combustion Chamber Design, S. L. Bragg and F. B. Holliday. Combustion in the Turbojet Engine, B. Way. Problems of Combustion under Altitude Condition (Treated from Fundamental Viewpoint), H. G. Wolfhard. Similarities in Combustion, A Review, A. E. Weller. Scaling of Gas Turbine Combustion Systems, D. G. Stewart. Recherche du Brûleur Optimum en Ecoulement Air-Kérosène à Grande Vitesse, B. Salmon and H. Vigne. Scaling of Liquid Fuel Rocket Combustion Chambers, C. C. Ross. Considerations on the Problem of Scaling Rocket Motors, L. Crocco.

Thermodynamic Tables and Other Data. Edited by R. W. Haywood. Cambridge, England, University Press; New York, Cambridge University Press, 1956. 23 pp., tables. $0.50.

Contents: General Data. Gas Data and Calorific Values. Steam Tables: (1) Triple-Point Data. (2) Saturated Water and Steam—Temperatures (32 to 212°F.). (3) Saturated Water and Steam—Pressures. (4) Internal Energy of Superheated Steam. (5) Enthalpy of Superheated Steam. (6) Entropy of Superheated Steam. (7) Density of Superheated Steam. (8) Compressed Liquid Water. Refrigerant Tables. (9) Ammonia. (10) Carbon Dioxide. (11) Freon-12. (12) Methyl Chloride.

Thermodynamics and Engineering; Publications from a Conference on Thermodynamics Held at the Pennsylvania State University, June 27–29, 1955. Edited by William E. Ranz. Sponsored by National Science Foundation and American Society for Engineering Education. University Park, Pa., Department of Engineering Research, Pennsylvania State University, 1955. 194 pp., illus., diagrs.

Contents: Thermodynamics and Irreversible Processes, Newman A. Hall. Concepts Employed in the Thermodynamics of Coupled Irreversible Flows, Joseph H. Keenan. Statistical Thermodynamics, R. Byron Bird. Relaxation Phenomena, Karl F. Herzfeld. Electrochemical Applications of Thermodynamics, J. J. Fritz. Some Applications of Thermodynamics to Electric and Magnetic Systems, Mark W. Zemansky. Elastomer Thermodynamics, Arthur V. Tobolsky. Heat Engine Applications of Thermodynamics, Chapman J. Walker. Applications of Thermodynamics in Distillation Calculations, Wayne C. Edmister. Rate Processes, Louis S. Kassel. Thermodynamics for All Engineering Students, George A. Hawkins.

Personnel Opportunities

This section is for the use of individual members of the Institute seeking new connections and organizations offering employment to Aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.

Wanted

The number preceding the notice represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

Supervisory Materials Engineer—$7,035 per annum. Duties (Condensed): Incumbent is head of the Materials Laboratory Branch, Materials and Process Division, Aeronautical Engineering Group, Overhaul and Repair Department. He assists the Materials Engineer (Division Superintendent) in accomplishing work of an engineering and administrative nature through counsel in planning and organization and by directing the personnel in the branch by immediate supervision. He is in charge of all laboratory work which embraces metallurgical investigations, analytical chemistry, and physical testing; acts as a project engineer and is directly in charge of the X-ray section. Qualifications (Condensed): A full 4-year course in an accredited college or university approved by the Engineer's Council for professional development leading to a Bachelor's degree plus 2½ years of progressive professional experience with at least 1 year of this experience in materials engineering or 6½ years of progessive technical engineering experience with at least 1 year of this experience in materials engineering. **Supervisory Production Metallurgist (Physical)**—$7,035 per annum. Duties (Condensed): Serves as head of the Metallurgical Branch, Materials and Process Division, Aeronautical Engineering Group, Overhaul and Repair Department. Assists the Division Head in accomplishing engineering and administrative work through counsel in planning and organization and by directing the personnel in the Metallurgical Branch. Responsible for preparation of all local process specifications, local engineering specifications, engineering instructions, reports, and other technical directives pertaining to metallurgical processes, including X-ray and nondestructive inspection. Directs all work required in the developing and establishing of new processes and makes periodic checks of processing methods used in various production shops to determine the need for technical improvements. Qualifications (Condensed): A full 4-year ccurse in an accredited college or university including 20 semester hours in metallurgical subjects, plus 2½ years of progressive practical experience or 6½ years of progessive technical experience. In each case, at least 2 years of this experience must have been in metallurgy. Application forms and further information may be secured from the Industrial Relations Officer, Industrial Relations Department, U.S. Naval Air Station, Quonset Point, R.I.

Engineering Assistant—In the field of theoretical and experimental stress analysis. Applicant should be a recent college graduate with a B.S. or M.S. in mechanical engineering. Mail qualifications to Brewer Engineering Laboratories, P.O. Box 157, Marion, Mass.

Air-Frame, Flight-Test, and Power-Plant Engineers—GS-5 to GS-12 levels; salaries ranging from $4,480 to $8,645 per annum. Positions are concerned with the development and administration of airworthiness standards; the design, evaluation, and testing of aircraft; and aircraft engines, propellers, equipment, electrical and electronic systems, and instruments for compliance with airworthiness standards. Grade level will be determined by the amount and quality of experience. Minimum qualifications are as follows: for GS-5—Bachelor's degree; for GS-7—degree plus 6 months' professional experience; for GS-9—degree plus 1½ years' professional experience; for GS-11—degree plus 2½ years' professional experience; and for GS-12—degree plus 3½ years' professional experience. Applicants should submit Standard Form 57, Application for Federal Employment, to the nearest CAA Personnel Office at the following locations: 16th & Constitution Avenue, N.W., Washington 25, D.C.; International Airport, Jamaica, L.I., N.Y.; P.O. Box 1689, Ft. Worth 1, Tex.; 911 Walnut Street, Kansas City 6, Mo.; P.O. Box 45007, Airport Station, Los Angeles.

Engineers—The Turbomotor Division of Curtiss-Wright Corporation is a new and rapidly expanding organization which will concentrate on the design and development of aircraft and missile propulsion systems in the low to medium power categories. Immediate openings exist for engineers qualified in the fields of compressor design, combustion, turbine design, mission analysis, and structural analysis. Starting salaries to $15,000, depending upon qualifications. A particularly attractive key position currently available is that of Performance Analysis Supervisor. Also available is a supervisory position in the field of Laboratory Operations. Send résumé to Nicholas Vrabel, Turbomotor Division, Curtiss-Wright Corporation, Princeton, N.J.

Electronic Scientists, Metallurgists, Physicists, Technologists, and Engineers (Aeronautical, Electrical, Electronic, Industrial, General, Mechanical, and Power-Plant)—The Naval Air Material Center, Philadelphia, has an urgent need for qualified engineering and scientific per-

INDEX TO ADVERTISERS seeking Engineering Personnel

COMPANY AND LOCATION	PAGE
AC Electronics Division, Milwaukee	180
Aerojet-General Corp., Azusa, Calif.	138
AiResearch Mfg. Divisions, Los Angeles; & Phoenix, Ariz.	102
Avco Defense & Industrial Products, Lawrence, Mass.	182
Bell Aircraft Corp., Buffalo	172
Boeing Airplane Co., Seattle; Wichita, Kan.; & Melbourne, Fla.	157
Caltech Jet Propulsion Laboratory, Pasadena, Calif.	175
Convair Division	
Pomono, Calif.	171
San Diego, Calif.	162
Cornell Aeronautical Laboratory, Buffalo	173
Douglas Aircraft Co., Inc., Santa Monica, Calif.	141
Fairchild Engine & Airplane Corp.	
Aircraft Division, Hagerstown, Md.	137
General Electric Co., Cincinnati; & Idaho Falls, Idaho	178
Philadelphia	181
West Lynn, Mass.	170
Johns Hopkins University, Silver Spring, Md.	178

COMPANY AND LOCATION	PAGE
Kaman Aircraft Corp., Bloomfield, Conn.	97
Lear, Inc., Santa Monica, Calif.	69
Link Aviation, Inc., Binghampton, N.Y.	166
Lockheed Aircraft Corp., Van Nuys & Sunnyvale, Calif.	159
Marquardt Aircraft Co., Van Nuys, Calif.	7, 142
The Glenn L. Martin Co., Denver	167
Minneapolis-Honeywell Regulator Co., Minneapolis	180
North American Aviation, Inc., Los Angeles	176
Columbus Division	145
Missile Development Div.	161
Northrop Aircraft, Inc., Hawthorne, Calif.	132
Pennsylvania State University, University Park, Pa.	170
Ramo-Wooldridge Corp., Los Angeles	170
Republic Aviation Corp., Farmingdale & Mineola, N.Y.	149, 178
Solar Aircraft Co., San Diego, Calif.	153
Southern Calif. Cooperative Wind Tunnel, Pasadena, Calif.	179
Systems Laboratories Corp., Sherman Oaks, Calif.	180
Temco Aircraft Corp., Dallas, Tex.	165
Trans World Airlines, Kansas City, Mo.	169

ENGINEERS

Aerodynamics & Propulsion

APL-An Organization Of And For Technical Men And Scientists

The Applied Physics Laboratory (APL) of the Johns Hopkins University is an organization *of* and *for* technical men and scientists. Several factors allow for more effective utilization of "mind power" at APL. They lead to tangible and intangible satisfactions for staff members that could not be gained elsewhere.

Among them are:

1. Individual staff members are given a measure of responsibility and initiative much greater than in many comparable establishments. Decision-making, on *all* levels, is placed in the hands of scientists and technical men.

2. Staff members do not restrict their efforts to limited technical problems. Instead they are asked to assess and solve problems of a systems nature, including analyses of *complete tactical problems.*

3. APL handles technical direction of the work of many associate and subcontractors, including 21 universities and leading industrial organizations. As a result, APL staff members enjoy a rewarding exchange of ideas and techniques with other leaders in R & D.

4. The combined facilities of APL, its associate and subcontractors, and Government test stations provide opportunities for members of its technical staff to develop and exploit their varied capabilities in a unique environment where teamwork and individual initiative are fused.

5. This *esprit* and freedom to look into new concepts have resulted in a number of "quantum jumps" in defense capability, including the proximity fuze, the first supersonic ramjet engine, and the Navy's Bumblebee family of missiles which includes TERRIER, TALOS and TARTAR. APL is presently attempting break-throughs on several important fronts.

APL's expansion program recently witnessed the completion of new laboratories covering 350,000 sq. ft. in Howard County, Maryland, equidistant from Washington, D. C. and Baltimore. Men of originality are invited to inquire about staff opportunities. Salaries compare favorably with those of other R & D organizations.

OPENINGS EXIST IN:

DEVELOPMENT: Stability and control analysis; ramjet engine design; preliminary design and wind-tunnel testing.

RESEARCH: Interference and heat transfer phenomena; internal aerodynamics; hypersonics, turbulence, shock wave phenomena; combustion.

For Additional information write: Professional Staff Appointments

The Johns Hopkins University Applied Physics Laboratory

8605 Georgia Avenue, Silver Spring, Md.

ENGINEER, ME AE

Aero-Thermodynamic Development On

Nuclear Aircraft Engine Units

The application of nuclear energy to aircraft flight requires the pooling of m any contributory talents. Genera Electric's ANP Department encourages the growth of such talents by offering the qualified engineer a work-environment that frees his creativeness while increasing his value.

Qualifications include 2 to 6 years' experience in thermodynamics and aerodynamic development. Work involves thermodynamic and fluid flow aspects of turbine type aircraft engines and components.

Openings at Cincinnati, Ohio and Idaho Falls, Idaho

Address replies, stating salary requirements, to location you prefer.

J. R. Rosselot
P. O. Box 132
Cincinnati, O.

L. A. Munther
P. O. Box 535
Idaho Falls, Idaho

GENERAL ELECTRIC

STRUCTURAL RESEARCH ENGINEER

...with aeronautical, mechanical or civil engineering degree and from 4 to 6 years of airframe structural analysis experience. Capable of designing test setups, conducting programs and preparing reports. Experience with strain measuring techniques desirable but not essential.

Employment at Republic includes company-paid hospitalization insurance, surgical insurance, accident, life insurance, tuition (2/3), 2-Fold Pension Plan, individual merit rated increases and many other benefits.

Send resume including details of your technical background to:

MR. DAVID G. REID
ENGINEERING PERSONNEL MGR.

REPUBLIC AVIATION CORP.

Farmingdale, L.I., N.Y.

sonnel to fill vacancies in the above positions. The Center is currently engaged in an extensive program of aeronautical research, development, experimentation, and test operations for the advancement of naval aviation. Starting salaries range from $4,480 to $7,570 per annum. Application for Federal Employment, Standard Form 57, should be filed with the Industrial Relations Department, Naval Air Material Center, Naval Base, Philadelphia 12. Applications may be obtained from the above address or from any first- or second-class post office.

Research Psychologists (Human Engineering, Training, and Systems Analysis)—The American Institute for Research has several openings for qualified personnel at the M.A. or Ph.D. level in the Systems and Human Engineering Program. Experience in human engineering, training and training equipment design, electronics, and maintenance is desirable. Salary ranges from $6,000 to $9,600 depending upon education and experience. Job duties consist of gathering field and laboratory data, designing experiments, evaluating existing methods and devices in the training and human engineering areas, and developing methods for training and human engineering applicable to industrial and military problems. Immediate openings available in Pittsburgh and Dayton, Ohio. Please send personal résumé, academic transcripts, and names of references to Ralph Ostrich, Systems and Human Engineering Program, 410 Amberson Avenue, Pittsburgh 32.

Instructor or Assistant Professor—Needed immediately to teach courses in the following: aircraft design; aeronautical laboratory courses in aerodynamics, instrumentation, propulsion, or structures; and other aeronautical courses. Salary will depend on education and experience; man with advanced degree preferred. If applicant desires to pursue graduate study, arrangements may be made for part-time schedule. Résumé of education and experience should be furnished in initial reply. Apply to Chairman, Department of Aeronautical Engineering, University of Kansas, Lawrence, Kan.

Research Physicists, Chemists, Mathematicians, Metallurgists, Engineers, and Aerodynamicists—The Research Laboratories of Ordnance Missile Laboratories seek qualified personnel to engage in fundamental research in the natural sciences and engineering. Unusual opportunities exist for original research in topics dealing with fluid dynamics, combustion, metallurgy, solid-state physics, nuclear physics, electronics, microwaves, mechanics, physical chemistry, inorganic and organic chemistry, mathematics, and others. Also, a graduate program through the University of Alabama allows continued study toward advanced degrees or self-improvement. Positions are available for grades GS-11 through GS-15 with corresponding salaries from $7,035 to $11,610 per annum. Ordnance Missile Laboratories is the Army Ordnance Research and Development Center for rockets and guided missiles. The Research Laboratories have the task of conducting the long-range research required to support the missile program. Applications may be submitted on Standard Form 57, Application for Federal Employment, which is available at any first- or second-class post office or from any Civil Service regional office. Correspondence should be addressed to Commanding General, Redstone Arsenal, Huntsville, Ala.; Attention: Dr. Eugene Miller, Research Laboratories.

Available

780. Administrator—Engineering—Pilot—B.S. Mech. Engrg. (Aero.), 1948. Former USAF instructor pilot and test pilot. Age 32. Five years as air-frame project engineer for AMC-WADC. Last 3 years as successful sales engineer for manufacturer of electromechanical air-borne equipment. Desires position of greater responsibility. Los Angeles area only. Please provide brief job description in first letter.

Class of '56...OR THEREABOUTS?

IF YOU'RE A FAIRLY RECENT GRADUATE, or getting your degree soon, you know the job situation. Whether you're thinking about your first job or considering a new one, just about everybody would like to tell you his story.

And we'd like to tell you our story—about working at the Southern California Cooperative Wind Tunnel, and about living in Pasadena. If you are interested in aerodynamic development, whatever your degree, we think you'll find a great many advantages here. CWT jobs offer challenge and variety. Southern California provides every kind of recreational activity and outstanding centers for advanced study.

No need to send a resume or make any immediate decisions. Just mail the coupon below for the CWT story.

CWT

Operated by the California Institute of Technology. Owned by Convair, Douglas, Lockheed, McDonnell and North American.

CWT is concerned with testing, analysing and solving aerodynamic problems involved in the development of high-speed aircraft and guided missiles.

Southern California Cooperative Wind Tunnel

952 South Raymond, Pasadena, California

GENTLEMEN: *Please send me literature about the Wind Tunnel.*

NAME_____

HOME ADDRESS_____

CITY_____ STATE_____

JOB TITLE_____

DEPARTMENT OF TECHNOLOGY
BUFFALO AN[illegible]KIE COUNTY PUBLIC LIBRARY

AERODYNAMICISTS

Honeywell's Aeronautical Division, the largest manufacturer of automatic pilots and associated flight control equipment, is continuing its program of expansion and diversification.

■ Our aerodynamic analysis group currently has openings for qualified aeronautical engineers with background and interest in aerodynamic analysis of closed loop systems and their relation to boundary layer control, flutter, buffeting and inlet geometry control.

■ These positions provide a variety of unusually interesting opportunities as our equipment is already scheduled for a number of supersonic aircraft and missiles, offering exceptional diversification in the aerodynamic field.

CONSIDER THESE ADVANTAGES

■ Minneapolis, the city of lakes and parks, offers you metropolitan living in a suburban atmosphere. No commuting.

■ Your travel and family moving expenses paid.

■ Salaries, insurance-pension programs, plant and technical facilities are all first-rate.

WRITE TO US

If you are interested in a permanent position with a sound, diversified growth company, call collect or send your résumé to Bruce Wood, Technical Director, Dept. T-4, Aeronautical Division, 1433 Stinson Boulevard, N.E., Minneapolis 13.

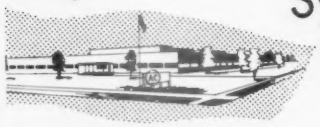
MINNEAPOLIS **Honeywell**

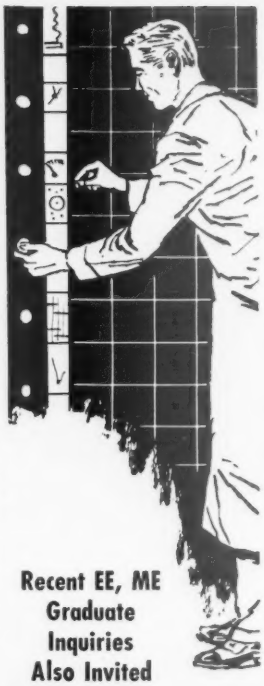
AERONAUTICAL DIVISION

Servo Engineers

ELECTRICAL MECHANICAL

Inertial Guidance System Program





Enjoy Challenging Opportunities in the further development and systems testing of Inertial Guidance Systems and their Servo Loops in the most versatile laboratories in the country.

Work with the top men in the field and with the finest test, research and development facilities. New plant being added in suburban Milwaukee as a part of Major, Permanent, Expansion Program.

AC will provide financial assistance towards your Master's Degree. A Graduate Program is available evenings at the University of Wisconsin, Milwaukee.

GM's long-standing policy of decentralization creates individual opportunity and recognition for each Engineer hired.

Milwaukee offers ideal family living combining small town hospitality with every metropolitan shopping and cultural advantage.

For personal, confidential interview in your locality send complete resume to

Mr. John F. Heffinger
Supervisor of Salaried Personnel

Recent EE, ME Graduate Inquiries Also Invited

THE ELECTRONICS DIVISION
GENERAL MOTORS CORPORATION
FLINT 2, MICH. • MILWAUKEE 2, WIS.

Land on the moon in fifteen years?

If your instinctive reaction to such a possibility is one of amused scepticism, this advertisement is not designed for you. But if your professional imagination is challenged by the prospect of actually contributing to man's first exploration of outer space, you will be interested in the opportunities that exist at Systems Laboratories for highly qualified engineers and scientists with leading-edge minds.

As the only organization of its kind primarily devoted to the research and development of interplanetary space travel, SLC has already attracted to its staff many of the country's foremost authorities in the fields of aero- and spacenautics. If you would like to work with these men on some of the most exciting projects of our time, send your resume directly to SLC's president, Dr. John L. Barnes. It will receive his prompt – and personal – attention.

SLC

SYSTEMS LABORATORIES CORPORATION

15016 Ventura Blvd., Sherman Oaks, Calif. in Los Angeles' San Fernando Valley

778. Aeronautical Engineer—Six years' progressive experience in varied aerodynamics projects involving airplane performance estimation, flight-test supervision, etc. B. of Ae.E. plus graduate work. Desires active responsible position involving aerodynamics and/or flight testing of aircraft, preferably in conjunction with actual flight duties.

777. Aeromechanical Engineer—B.S. in M.E. Many years' experience as project leader in research, development, and product engineering in the fields of propulsion (jet engines and rockets), hydrodynamics, structures, and missile design. Cooriginator of an important new missile. Thoroughly experienced in project costs, production and quality control, handling subcontracts, liaison with defense agencies, and supervision of large groups.

776. Contract Administration or Administrative Engineering—B.S. in Aeronautical Engineering. Has almost completed Master's degree in Industrial Management. 7 years' Air Force experience as aircraft weapons system project officer—project engineering, procurement and production. Prefers New York City area. Résumé sent upon request.

775. Staff or Executive Engineer—Outstanding in ability to correlate between scientific, engineering, production, management, and supplier organizations. Can assist top executive or administer group in mechanical or related fields. Broad coverage of light to heavy mechanical activities through 21 years of integrated management, design, development, and research. Broad progressive interests, registered, advanced degree. Salary five figures plus.

THE IAS LIBRARY

Publications treated in the "Aeronautical Reviews" sections are maintained by the Library for use by the IAS Membership. They are *not* for sale but are made available through the facilities of the Library.

LENDING SERVICES: Institute members, both Individual and Corporate, may borrow periodicals, reports, and books for a period of 2 weeks, excluding time in transit. Excepted are certain reference books and those IAS publications that may be purchased.

PHOTOCOPY SERVICES: The Library is equipped to provide, as a service, positive photocopies of certain materials in its collections. Rates on request.

For detailed information about these and other services, write to:

John J. Glennon, Librarian
Institute of the
Aeronautical Sciences, Inc.
2 East 64th Street
New York 21, New York

NOW AVAILABLE
TO ENGINEERS & SCIENTISTS

The Papers Presented at the Guided Missiles Technical Forums

HELD BY THE
MISSILE & ORDNANCE SYSTEMS DEPARTMENT
OF GENERAL ELECTRIC

The Technical Forums held by authorities from the Missile & Ordnance Systems Department (then called the Special Defense Projects Department), of General Electric in New York City and Buffalo last Spring were unusually well received, attracting large audiences of engineers and scientists interested in keeping up with the very latest developments in the field of Guided Missiles.

In view of the intense interest in these forums, and the subsequent requests for reprints of the papers presented, we have decided to make them available upon request.

Papers presented were on the following subjects:

SOME AEROPHYSICS PROBLEMS CONNECTED WITH HYPERSONIC FLIGHT
by Dr. John W. Bond, Jr.—*Aerophysicist*

PROBLEMS OF SYSTEMS ENGINEERING
by Mr. A. W. Robinson—*Manager, Systems Engineering*

EXPERIMENTS IN HYPERSONICS
by Dr. Yusuf A. Yoler—*Hypersonic Scientist*

THE INTEGRATION OF SYSTEMS TEST
by Mr. William R. Eaton—*Manager, Quality Control and Test Engineering*

MISSILE AEROPHYSICS
by Dr. Joseph Farber—*Manager, Aerophysics*

STRUCTURAL FRONTIERS
by Mr. Samuel Levy—*Manager, Stress Analysis Engineering*

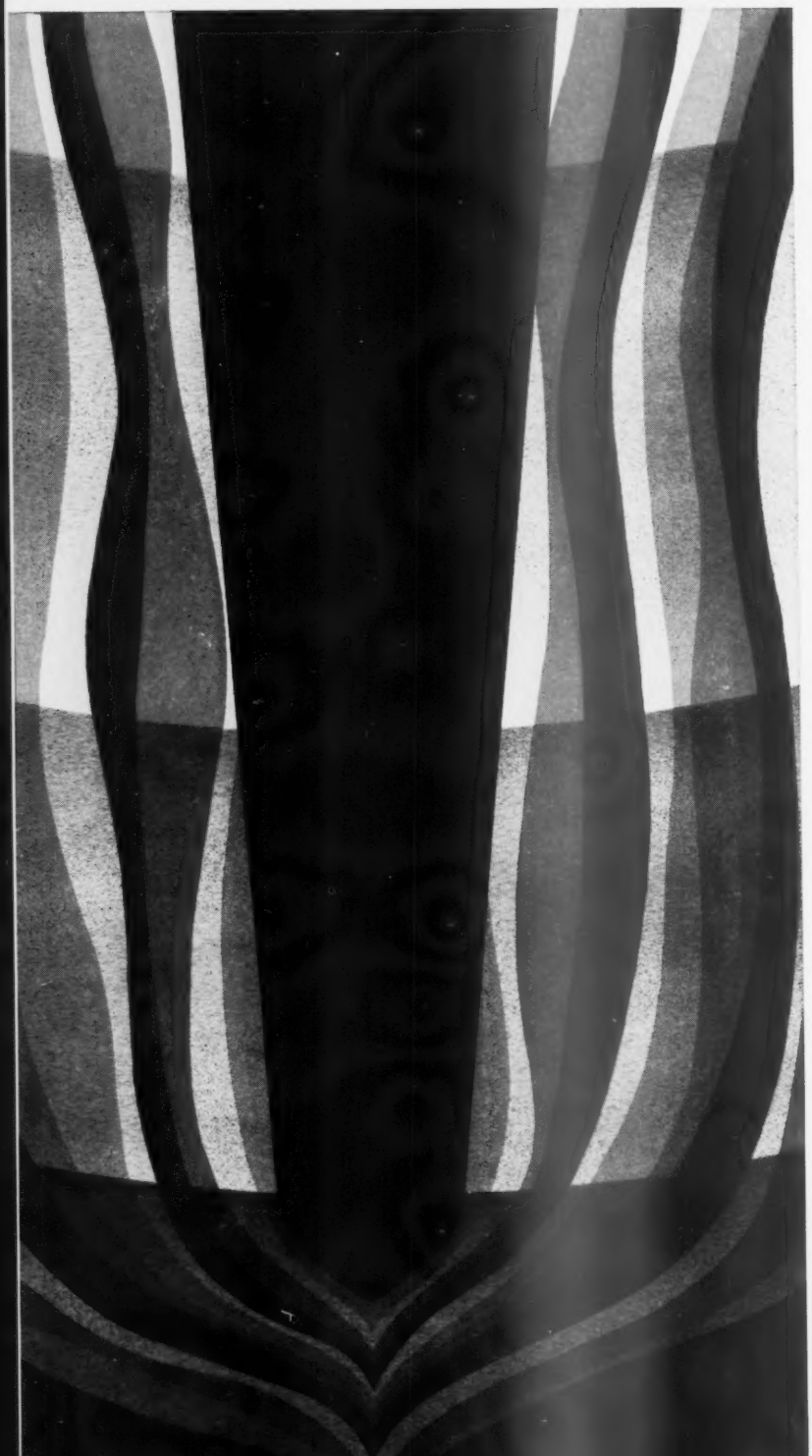
To receive your set of these papers, collected in a convenient folder, please write:
TECHNICAL FORUM, ROOM 508-2

MISSILE AND ORDNANCE SYSTEMS DEPARTMENT

GENERAL ELECTRIC

3198 Chestnut Street, Philadelphia 4, Pa.

AVCO makes 18,000 mph stand still!



AVCO makes 18,000 mph stand still . . . with the Hypersonic Shock Tube. This AVCO development simulates, on stationary materials, the effects of 18,000 mph speeds to hasten perfection of an advanced Air Force missile system. This and many other challenging projects await you at AVCO.

Opens new frontiers for young engineers and scientists

Vast, new areas in research have been thrown open by AVCO's new Hypersonic Shock Tube. The effects of speeds to 18,000 mph can now be observed *on a stationary model within the Tube.* The findings are helping to hasten development of an advanced Air Force missile system.

For forward-looking young engineers and scientists—for men with two, three or more years of experience—this is creating great opportunities; first in missiles, eventually in any or all physical sciences, in an atmosphere of technical sophistication and free inquiry.

Interested in this kind of a future? In the advantages of living in a lovely, lake-dotted countryside? In easy access to the entertainment, shopping, educational and cultural facilities of Boston? In a liberal educational assistance program?

Mail your résumé to Dr. Lloyd P. Smith, Pres., Room 413M, AVCO Research and Advanced Development Division, 20 South Union Street, Lawrence, Mass. Or phone Murdock 8-6011.

PHYSICAL SCIENTISTS ENGINEERS

Development • Design • Analytical

Required:
advanced or Bachelor degree with Major in

SCIENCE	ENGINEERING
PHYSICS	MECHANICAL
MATHEMATICS	SYSTEMS
AERODYNAMICS	ELECTRICAL
METALLURGY	STRESS
ELECTRONICS	DESIGN

You will work on research and development in Lawrence or Everett, Mass., in these areas:

Radar • Weapons Systems • Guidance • Telemetering • Instrumentation • Miniaturization • Control Computing • High-temperature Alloys • Cermets Experimental Fabrication • Aerodynamics Design and Analysis • Gyroscopics • Ballistics • Physical Property Determination • Dynamics • Data Processing • Structures • Heat Transfer • Radiation Chemistry • Servo Mechanisms. **Additional opportunities for Test Engineers • Technicians • Draftsmen.**

avco Research and Advanced Development division

Index to the

Aeronautical Engineering Review, Volume 15

January–December, 1956

	Month	Page
ABRAHAM, LEWIS H. Techniques and Problems in Testing Structures at Elevated Temperatures	*Nov.*	56
Accessories & Components—		
Accessory Drive Turbines for Aircraft and Missiles, O. E. Baljé	*Mar.*	60
Aircraft Armament Equipment, R. E. Kemelhor	*Sept.*	48
Calculation of Feel Cam Contour, Jack E. Brooks	*Sept.*	37
The Floating Integrating Gyro and Its Application to Geometrical Stabilization Problems on Moving Bases, C. S. Draper, W. Wrigley, and L. R. Grohe	*June*	46
The Impact of Electronic Equipment on Electric Generator Design and Aircraft Power Plants, Henry Rempt and M. J. Cronin	*May*	87
Mass Flowmeter Summation System, Clarence A. Haskell	*July*	54
Pneumatic Ducting Systems, William M. Cattrell	*Mar.*	68
The Problem of Cooling Electronic Equipment in High-Performance Aircraft, Nathan A. Carhart	*May*	76
Aerodynamics—		
Delay of the Stall by Suction Through Distributed Perforations, August Raspet, Joseph J. Cornish III, and Glenn D. Bryant	*Aug.*	32
Drag and Stability of Parachutes, Helmut G. Heinrich	*June*	73
Experimental Hyperballistics, H. H. Kurzweg and R. E. Wilson	*Dec.*	32
Lift on a Wing in a Propeller Slipstream as Related to Low-Speed Flight, Scott Rethorst	*Oct.*	42
Prediction of Downwash at Various Angles of Attack for Arbitrary Tail Locations, James L. Decker	*Aug.*	22
The Problem of Aerodynamic Heating, E. R. van Driest	*Oct.*	26
Some Aerodynamic Considerations of Nozzle-Afterbody Combinations, Edgar M. Cortright, Jr.	*Sept.*	59
Zero-Lift-Drag Characteristics of Wing-Body Combinations at Transonic Speeds, Richard T. Whitcomb	*June*	42
Air Transport—		
Air Traffic Facts, A. D'Arcy Harvey	*July*	58
Aircraft Noise as It Relates to the Airport Neighbor, Vice-Adm. Charles E. Rosendahl, USN (Ret.)	*June*	71
The Economics of Large Aircraft, Grover Loening	*Apr.*	48
A Graphical Method for Determining the Aerodynamic and Economic Characteristics of Turboprop Air-Line Transport Systems, Ralph W. Allen	*Dec.*	55
Passenger Air-Line Economics, Lloyd B. Aschenbeck	*Dec.*	39
STOL Airplanes—A New Approach to Air Transport, R. A. Darby	*Mar.*	48
ALLEN, RALPH W. A Graphical Method for Determining the Aerodynamic and Economic Characteristics of Turboprop Air-Line Transport Systems	*Dec.*	55
ALLISON, G. P., AND R. J. HENDERSON. Aircraft Electronic Equipment—Contoured Versus Standard	*May*	58
ANAST, JAMES L. Common System Development—1956	*May*	98
ASCHENBECK, LLOYD B. Passenger Air-Line Economics	*Dec.*	39
BALJÉ, O. E. Accessory Drive Turbines for Aircraft and Missiles	*Mar.*	60
BATTAN, LOUIS J. Vertical Scanning Air-Borne Radar for Reducing Hazards of Aircraft Icing and Ground Collisions	*Dec.*	52
BONNALIE, A. F. Safety and Economic Aspects of Flight Simulators	*Oct.*	71
BRANTLEY, J. Q., JR. The In-Flight Collision Problem	*July*	45
BROOKS, JACK E. Calculation of Feel Cam Contour	*Sept.*	37
BROSTERHOUS, CLAUDE A., AND HUGH B. THOMPSON. Recent Developments in Braking of High-Speed Test Vehicles	*Dec.*	26
BRYANT, GLENN D., AUGUST RASPET, AND JOSEPH J. CORNISH III. Delay of the Stall by Suction Through Distributed Perforations	*Aug.*	32
CARHART, NATHAN A. The Problem of Cooling Electronic Equipment in High-Performance Aircraft	*May*	76
CARHART, RICHARD C. Growing a Reliable Missile	*Feb.*	28
CATTRELL, WILLIAM M. Pneumatic Ducting Systems	*Mar.*	68
COLE, G. H. A Precision Servo-Type Thermocouple Temperature Indicating System	*May*	94
CORNISH, JOSEPH J., III, AUGUST RASPET, AND GLENN D. BRYANT. Delay of the Stall by Suction Through Distributed Perforations	*Aug.*	32
CORNOG, ROBERT. Economics of Rocket-Propelled Airplanes—Part I	*Sept.*	30

	Month	Page
CORNOG, ROBERT. Economics of Rocket-Propelled Airplanes—Part II	*Oct.*	49
CORTRIGHT, EDGAR M., JR. Some Aerodynamic Considerations of Nozzle-Afterbody Combinations	*Sept.*	59
CRONIN, M. J., AND HENRY REMPT. The Impact of Electronic Equipment on Electric Generator Design and Aircraft Power Plants	*May*	87
DARBY, R. A. STOL Airplanes—A New Approach to Air Transport	*Mar.*	48
DAVIS, GROUP CAPT. R. C., RCAF. Aircraft Accident Investigation	*Feb.*	37
DECKER, JAMES L. Prediction of Downwash at Various Angles of Attack for Arbitrary Tail Locations	*Aug.*	22
DE FLOREZ, LUIS, AND E. K. SMITH. Helicopter Flight Trainer	*May*	114
DEMLER, BRIG. GEN. MARVIN C. Aims of the Air Force Development Program in Aeronautics and Propulsion	*Oct.*	59
Design		
Air Operations Consciousness in Aeronautical Engineering, Ralph H. Miner	*Mar.*	72
Calculation of Feel Cam Contour, Jack E. Brooks	*Sept.*	37
Delay of the Stall by Suction Through Distributed Perforations, August Raspet, Joseph J. Cornish III, and Glenn D. Bryant	*Aug.*	32
Drag and Stability of Parachutes, Helmut G. Heinrich	*June*	73
The Economics of Large Aircraft, Grover Loening	*Apr.*	48
Induction System Selection, Harry Drell and Thomas A. Sedgwick	*Nov.*	67
Noise, Vibration, and Aircraft Structures, Arthur A. Regier	*Aug.*	56
Nuclear Aircraft Shielding, A. P. Fraas	*Sept.*	39
Pneumatic Ducting Systems, William M. Cattrell	*Mar.*	68
Prediction of Downwash at Various Angles of Attack for Arbitrary Tail Locations, James L. Decker	*Aug.*	22
The Problem of Aerodynamic Heating, E. R. van Driest	*Oct.*	26
Problems in the Design of Propeller-Driven Vertical Take-Off Transport Airplanes, M. O. McKinney, R. E. Kuhn, and J. B. Hammack	*Apr.*	68
Silencing the Jet Aircraft, Holden W. Withington	*Apr.*	56
Some Aerodynamic Considerations of Nozzle-Afterbody Combinations, Edgar M. Cortright, Jr.	*Sept.*	59
Surface-Protection and Cooling Systems for High-Speed Flight, D. J. Masson and Carl Gazley, Jr.	*Nov.*	46
Thermal Stresses and Deformations in Beams, Samuel Levy	*Oct.*	62
Unique Structural Problems in Supersonic Aircraft Design, F. P. Mitchell	*Jan.*	34
Zero-Lift-Drag Characteristics of Wing-Body Combinations at Transonic Speeds, Richard T. Whitcomb	*June*	42
DIX, E. H., JR. Aluminum Alloys for Elevated Temperature Service	*Jan.*	40
DOW, NORRIS F. A Re-Evaluation of Some Air-Frame Thermal Problems	*Nov.*	61
DRAPER, C. S., W. WRIGLEY, AND L. R. GROHE. The Floating Integrating Gyro and Its Application to Geometrical Stabilization Problems on Moving Bases	*June*	46
DRELL, HARRY, AND THOMAS A. SEDGWICK. Induction System Selection	*Nov.*	67
DUNCAN, D. B., AND J. M. SLATER. Inertial Navigation	*Jan.*	49
Editorial—		
America's Capacity to Maintain Technological Leadership, James R. Killian, Jr.	*Apr.*	38
Electronics in Aviation, H. Guyford Stever	*May*	57
The First 289 Years Were the Hardest	*June*	41
Forty Years in Aviation . . . 80 Years Young	*Aug.*	16
Here We Go Again!	*Oct.*	24
IAS President 1956—IAS President 1955	*Mar.*	46
In Memoriam—Lester Durand Gardner . . 1876–1956	*Dec.*	24
The Job Before Us	*July*	26
Glenn L. Martin, 1886–1955	*Feb.*	26
Mid-Term Report	*Nov.*	44
A New IAS Service	*Jan.*	24
Progress Report—Vocational Guidance	*Sept.*	29
Education & Training—		
America's Capacity to Maintain Technological Leadership (*Editorial*), James R. Killian, Jr.	*Apr.*	38
Helicopter Flight Trainer, Luis de Florez and E. K. Smith	*May*	114
Electronics & Electrical Equipment—		
Aircraft Electronic Equipment—Contoured Versus Standard, R. J. Henderson and G. P. Allison	*May*	58
Cooling Procedures Necessary to Avionic Reliability, James P. Welsh	*May*	110
Electronics in Aviation (*Editorial*), H. Guyford Stever	*May*	57
The Impact of Electronic Equipment on Electric Generator Design and Aircraft Power Plants, Henry Rempt and M. J. Cronin	*May*	87
Integrated Flight Equipment System with Primary Emphasis on Instrumentation and Controls, C. F. Fragola and M. A. Sant Angelo	*May*	62
Navy Requirements for Air Navigational Aids, Communications Facilities, and Air Traffic Control, 1955–1975, H. I. Rothrock	*May*	82
Operational Digital Techniques for Special Purpose Computers, R. N. Nicola	*Mar.*	78
A Precision Servo-Type Thermocouple Temperature Indicating System, G. H. Cole	*May*	94
The Problem of Cooling Electronic Equipment in High-Performance Aircraft, Nathan A. Carhart	*May*	76
Some Principles of Missile Guidance, Col. Richard C. Gibson, USAF	*May*	70
EVANS, COL. RICHARD E., USAF. Operational Aspects of the SAC Transition to Jets	*Nov.*	86
Flight Propulsion—		
Aims of the Air Force Development Program in Aeronautics and Propulsion, Brig. Gen. Marvin C. Demler, USAF	*Oct.*	59
Economics of Rocket-Propelled Airplanes—Part I, Robert Cornog	*Sept.*	30
Economics of Rocket-Propelled Airplanes—Part II, Robert Cornog	*Oct.*	49
Guided-Missile Propulsion, T. J. Keating	*June*	67

	Month	Page
Flight Propulsion, *Continued*—		
Induction System Selection, Harry Drell and Thomas A. Sedgwick	*Nov.*	67
Mass Flowmeter Summation System, Clarence A. Haskell	*July*	54
Nuclear Aircraft Shielding, A. P. Fraas	*Sept.*	39
The Problems of the Turbojet Engine as a Propulsion Engine for Supersonic Flight, M. J. Zucrow	*Dec.*	44
Silencing the Jet Aircraft, Holden W. Withington	*Apr.*	56
The Turbine-Propeller Combination in the Air Force, Lt. Col. Roy J. Wellman, USAF	*Aug.*	40
Flight Simulators—		
Flight Application of Target-Simulator Principles, William M. Kauffman	*Nov.*	76
Helicopter Flight Trainer, Luis de Florez and E. K. Smith	*May*	114
Safety and Economic Aspects of Flight Simulators, A. F. Bonnalie	*Oct.*	71
Flight Testing—		
Air Operations Consciousness in Aeronautical Engineering, Ralph H. Miner	*Mar.*	72
Recent Developments in Braking of High-Speed Test Vehicles, Claude A. Brosterhous and Hugh B. Thompson	*Dec.*	26
FRAAS, A. P. Nuclear Aircraft Shielding	*Sept.*	39
FRAGOLA, C. F., AND M. A. SANT ANGELO. Integrated Flight Equipment System with Primary Emphasis on Instrumentation and Controls	*May*	62
FURTH, REAR ADM. F. R., USN (RET.). Project VANGUARD—The International Geophysical Year Earth Satellite	*Mar.*	55
GAZLEY, CARL, JR., AND D. J. MASSON. Surface-Protection and Cooling Systems for High-Speed Flight	*Nov.*	46
GIBSON, COL. RICHARD C. Some Principles of Missile Guidance	*May*	70
GROHE, L. R., W. WRIGLEY, AND C. S. DRAPER. The Floating Integrating Gyro and Its Application to Geometrical Stabilization Problems on Moving Bases	*June*	46
HAMMACK, J. B., R. E. KUHN, AND M. O. MCKINNEY. Problems in the Design of Propeller-Driven Vertical Take-Off Transport Airplanes	*Apr.*	68
HAMMILL, I. J., AND E. R. ZEEK. Crash Fire Prevention—Research to Flight Test	*July*	40
HARRISON, HENRY T. The Display of Hail Echoes on 5.5-Cm. Weather Mapping Radar	*May*	102
HARVEY, A. D'ARCY. Air Traffic Facts	*July*	58
HASKELL, CLARENCE A. Mass Flowmeter Summation System	*July*	54
HEINRICH, HELMUT G. Drag and Stability of Parachutes	*June*	73
HENDERSON, R. J., AND G. P. ALLISON. Aircraft Electronic Equipment—Contoured Versus Standard	*May*	58
HINZ, EARL R., WALTER TYDON, AND A. N. PETROFF. VTOL-STOL Aircraft (A Compendium) Part I	*July*	28
HOFF, N. J. Experiment and Theory in the Investigation of the Behavior of Structures at High Temperatures	*Feb.*	39
HUNTER, H. F. The Structural Damping of Titanium at Elevated Temperature	*Aug.*	18
Institute of the Aeronautical Sciences—		
AGARD Meetings in Rome	*May*	52
Allied Research Associates Is New IAS Corporate Member	*Dec.*	21
American Helicopter Society Holds Third Western Forum	*Nov.*	39
American Helicopter Society's Twelfth Annual Forum in Washington Sets Record for Attendance	*Aug.*	12
Anniversary Volume Honors Sir Geoffrey Taylor	*June*	38
Annual Business Meeting of the Institute	*Mar.*	35
Atlanta Section Sponsors Southeastern Regional Conference at Georgia Tech for IAS Student Branches	*July*	20
British Scientist to Deliver Wright Lecture	*Nov.*	35
Brown University Host to Engineering Schools at Northeastern Student Conference	*July*	19
W. A. M. Burden Named Trustee of Columbia	*Apr.*	36
Burden on Lockheed Board	*May*	52
CAI-IAS International Meeting at Ottawa	*Jan.*	20
Civil Service League Honors Ezra Kotcher	*Sept.*	25
Collected Works of von Kármán to Be Published	*June*	38
Conference on Aeronautical Electronics	*Apr.*	35
Consulting Firm Formed	*Sept.*	25
Admiral de Florez Heads Flight Safety Foundation	*Mar.*	40
Director's Report—1955	*Mar.*	36
Donald Douglas Lauded; Tribute Put in Congressional Record	*Nov.*	41
Donald W. Douglas Wins Elmer A. Sperry Award	*Aug.*	13
Dues Standardized by Council Action	*Oct.*	20
W. F. Durand Receives Diploma After 76 Years	*Nov.*	40
Educators Discuss Cooperative Programs with West Coast Industry	*Sept.*	23
Eleventh Flight Propulsion Meeting	*June*	35
Employee Relations	*July*	20
Fellowships in the Institute—1955	*Mar.*	43
First Minta Martin Student Awards Are Presented	*Mar.*	40
Flight Safety Officials	*July*	20
Flight-Test Fellowship Worth Almost $5,000	*Nov.*	40
C. C. Furnas Appointed to Defense Post	*Feb.*	23
C. C. Furnas Receives Vincent Bendix Award	*Sept.*	24
I. E. Garrick Chosen for Hunsaker Chair at M.I.T.	*Sept.*	24
General Dynamics Corporation Joins the Institute	*July*	21
Guggenheim Fellowships Open	*Mar.*	85
Harry Guggenheim Honored	*May*	52
R. Paul Harrington Is Named Director of AGARD Training Center in Belgium	*Dec.*	20
Hoff Lectures in Europe Under AGARD Auspices	*Apr.*	36
Honorary Fellows for 1955	*Mar.*	43
Hunsaker and Land Honored by Aeronautic Association	*Dec.*	21
Hyatt's Award Not for VTO	*Feb.*	24
IAS Awards and Honors for 1955	*Mar.*	44
IAS Compiling Catalog of 1,700 Technical Films	*Jan.*	22
IAS Day at Wright-Patterson AFB	*Feb.*	21
IAS Is Among Sponsors of Air Transport Symposium	*Oct.*	21

	Month	Page
Institute of the Aeronautical Sciences, *Continued*—		
IAS *Journal* Honors von Kármán	*May*	52
IAS Member Is Officer in New Aerophysics Firm	*Oct.*	21
IAS Officers for 1956	*Mar.*	42
IAS Opens Competition for Fellowship in Flight Test; Forms Available Now	*Oct.*	20
IAS President Predicts Challenge of Flight Will Succumb to Research and Teamwork	*Nov.*	38
IAS Roster of Members	*Aug.*	14
Tex Johnston Wins Chanute Award	*Aug.*	11
Casey Jones Honored for Training Technicians	*Sept.*	24
Kartveli, Bowman, and O'Donnell Get New Posts at Republic	*Nov.*	40
Lear Engineering Scholarship	*Sept.*	26
C. W. Lemmerman, Inc., New Corporate Member	*Nov.*	41
A Letter to the Editor	*Sept.*	25
MAA Continues Officers	*Apr.*	37
Marquardt Engineers Sponsor "Science Scouts"	*Sept.*	23
McDonnell Aircraft Corp. Forms Research Dept.	*Aug.*	13
Mid-Continent Manufacturing Joins the Institute	*June*	38
The National Summer Meeting	*May*	51
National Summer Meeting Dinner	*Sept.*	20
National Summer Meeting Report	*Sept.*	19
NATO Scientists Meet at AGARD Session on Guided Missiles	*July*	23
New Division of ARDC	*May*	22
New Scholarship Fund Is Announced at M.I.T.	*Dec.*	20
Newly Elected Members of the Institute Council	*Mar.*	41
The Nineteenth Wright Brothers Lecture	*Feb.*	19
Norden-Ketay Corporation a New Member of IAS	*June*	39
Ralph M. Parsons Company Joins the Institute	*Aug.*	14
President's Report—1955	*Mar.*	35
Replica of Lindbergh's Plane for Air Force Academy	*Aug.*	14
Republic Forms Staff for Advanced Scientific Research	*July*	22
Rest Home in Italy May Bear Wilbur Wright Name	*Nov.*	42
Sandberg-Serrell Corporation Joins the Institute	*Feb.*	24
Satin Wins Service Award for Outstanding Leadership	*Nov.*	42
Schubauer Wins Gold Medal for Aerodynamic Research	*July*	22
Separate Acoustics Unit Is Established at Douglas	*Oct.*	20
E. R. Sharp Elected President for 1956	*Jan.*	19
Sigma Gamma Tau	*Apr.*	37
Sixth Annual West Coast Student Conference Attracts a Record Attendance of 200	*Sept.*	22
Skyways Lead to Canada Nov. 26, 27 for Third Annual CAI-IAS Conference	*Oct.*	19
Sir Richard Southwell Is Visiting Professor at Rice	*Sept.*	24
Stever Is Given USAF Award for Work as Chief Scientist	*Oct.*	20
Students Present Papers in Eight Competitions	*Apr.*	36
Swedish Society's '56 Medal Awarded to A. M. Freudenthal	*Dec.*	21
Ten IAS Members Named "Elder Statesmen of Aviation"	*Feb.*	23
Thiokol Chemical Corporation Joins the Institute	*May*	52
The Third National Turbine-Powered Air Transportation Meeting, San Diego, Calif.	*Nov.*	36
Thirteen Colleges Represented at Texas Section's Fourth Southwestern Student Paper Competition	*July*	18
Treasurer's Report—1955	*Mar.*	36
Turbine-Powered Air Transport Meeting	*July*	17
Twelve Technical Papers Will Be Delivered at Third CAI-IAS Meeting in Toronto	*Nov.*	35
25 Sessions, Panel Discussions Set for Institute's 25th Annual Meeting	*Dec.*	19
Two Corporate Members of IAS Among Founders of New Firm	*Dec.*	20
Two IAS Members Reappointed Guggenheim Fellows	*Oct.*	21
Uniterm Index Issued by Pacific Aeronautical Library	*Apr.*	36
University of Maryland Draws Five Schools to First Middle Atlantic Student Conference	*July*	21
USAF Research Office Moves	*Aug.*	14
Weber Aircraft Joins IAS as a Corporate Member	*May*	53
R. T. Whitcomb of NACA Wins Collier Trophy	*Jan.*	22
Richard Whitcomb Wins NACA's Top Award for Discovery, Verification of Area Rule	*Dec.*	21
White House Names Bassett to Head Airways Study Unit	*Nov.*	40
Wright Brothers Memorial Trophy Goes to H. L. Dryden	*Jan.*	22
Wilbur Wright Elected to N.Y.U. Hall of Fame	*Jan.*	23
Wright Lecturer Chosen	*Aug.*	14
Instruments—		
Common System Development—1956, James L. Anast	*May*	98
The Display of Hail Echoes on 5.5-Cm. Weather Mapping Radar, Henry T. Harrison	*May*	102
The Floating Integrating Gyro and Its Application to Geometrical Stabilization Problems on Moving Bases, C. S. Draper, W. Wrigley, and L. R. Grohe	*June*	46
Integrated Flight Equipment System with Primary Emphasis on Instrumentation and Controls, C. F. Fragola and M. A. Sant Angelo	*May*	62
Operational Digital Techniques for Special Purpose Computers, R. N. Nicola	*Mar.*	78
Pilot, Instruments, Controls, Gilbert L. Roth	*Sept.*	66
A Precision Servo-Type Thermocouple Temperature Indicating System, G. H. Cole	*May*	94
Trends in Autopilot Developments, William P. Lear	*Jan.*	26
Vertical Scanning Air-Borne Radar for Reducing Hazards of Aircraft Icing and Ground Collisions, Louis J. Battan	*Dec.*	52
JENSEN, JORGEN. Satellites	*Sept.*	44
KAPLAN, JOSEPH. Rocket and Satellite Studies During the IGY	*Apr.*	64
KAUFFMAN, WILLIAM M. Flight Application of Target-Simulator Principles	*Nov.*	76
KEATING, T. J. Guided-Missile Propulsion	*June*	67
KEMELHOR, R. E. Aircraft Armament Equipment	*Sept.*	48
KILLIAN, JAMES R., JR. America's Capacity to Maintain Technological Leadership (*Editorial*)	*Apr.*	38
KIRCHNER, OTTO E. Air Safety	*Feb.*	48

	Month	Page
KUHN, R. E., M. O. MCKINNEY, AND J. B. HAMMACK. Problems in the Design of Propeller-Driven Vertical Take-Off Transport Airplanes	*Apr.*	68
KURZWEG, H. H., AND R. E. WILSON. Experimental Hyperballistics	*Dec.*	32
LEAR, WILLIAM P. Trends in Autopilot Developments	*Jan.*	26
LEVY, SAMUEL. Thermal Stresses and Deformations in Beams	*Oct.*	62
LOENING, GROVER. The Economics of Large Aircraft	*Apr.*	48
MALONEY, W. J., JR. The Application of Nondestructive Testing by a Manufacturer of Military Aircraft	*Apr.*	76
MASSON, D. J., AND CARL GAZLEY, JR. Surface-Protection and Cooling Systems for High-Speed Flight	*Nov.*	46
Materials—		
Aircraft Armament Equipment, R. E. Kemelhor	*Sept.*	48
Aluminum Alloys for Elevated Temperature Service, E. H. Dix, Jr.	*Jan.*	40
Materials and Fabrication Techniques for Structural Heat-Resistant Plastic Sandwiches, Norman E. Wahl	*Feb.*	34
A Re-Evaluation of Some Air-Frame Thermal Problems, Norris F. Dow	*Nov.*	61
The Structural Damping of Titanium at Elevated Temperature, H. F. Hunter	*Aug.*	18
Surface-Protection and Cooling Systems for High-Speed Flight, D. J. Masson and Carl Gazley, Jr.	*Nov.*	46
MCKINNEY, M. O., R. E. KUHN, AND J. B. HAMMACK. Problems in the Design of Propeller-Driven Vertical Take-Off Transport Airplanes	*Apr.*	68
Meeting Reports—		
Air Safety, Otto E. Kirchner	*Feb.*	48
A Digest of Summer Meeting Papers	*Oct.*	76
24th Annual Meeting—Summary of Technical Sessions	*Apr.*	42
Military Aviation—		
Aims of the Air Force Development Program in Aeronautics and Propulsion, Brig. Gen. Marvin C. Demler, USAF	*Oct.*	59
The Application of Nondestructive Testing by a Manufacturer of Military Aircraft, W. J. Maloney, Jr.	*Apr.*	76
Flight Application of Target-Simulator Principles, William M. Kauffman	*Nov.*	76
Navy Requirements for Air Navigational Aids, Communications Facilities, and Air Traffic Control, 1955–1975, H. I. Rothrock	*May*	82
The New Naval Aviation Safety Program, Comdr. A. L. Rasmussen, USN	*Aug.*	28
Operational Aspects of the SAC Transition to Jets, Col. Richard E. Evans, USAF	*Nov.*	86
The Planning of Systems and Products for the Military Services, L. L. Stahl	*June*	63
STOL-VTOL Aircraft in the Air Mobile Army, Lt. Col. Michael J. Strok, USA	*Nov.*	81
The Turbine-Propeller Combination in the Air Force, Lt. Col. Roy J. Wellman, USAF	*Aug.*	40
MINER, RALPH H. Air Operations Consciousness in Aeronautical Engineering	*Mar.*	72
MITCHELL, F. P. Unique Structural Problems in Supersonic Aircraft Design	*Jan.*	34
Navigation—		
All-Weather Flight Concern of the Pilot and Weather Forecaster, James K. Thompson	*July*	63
Common System Development—1956, James L. Anast	*May*	98
The Display of Hail Echoes on 5.5-Cm. Weather Mapping Radar, Henry T. Harrison	*May*	102
Inertial Navigation, J. M. Slater and D. B. Duncan	*Jan.*	49
The In-Flight Collision Problem, J. Q. Brantley, Jr.	*July*	45
Necrology—		
Willard J. Amick	*Mar.*	85
Harry T. Brackett	*June*	39
Edward W. Breen	*Feb.*	24
Joseph N. Cariola	*May*	53
Stewart W. Cogswell	*Dec.*	22
Ralph S. Damon	*Mar.*	85
Zulime W. Diehl	*June*	39
Carl Dienstbach	*Sept.*	26
William M. Drake	*Dec.*	22
Sir Richard Fairey	*Dec.*	22
Earl V. Farrar	*Oct.*	21
Joseph J. Hill	*Sept.*	26
Carl Hinshaw	*Oct.*	21
Eugene Barton Hoffman	*Oct.*	22
Willard A. Hoffman	*July*	24
Richard J. Hruda	*Feb.*	24
Lt. Paul D. Jacobs	*July*	24
Berneice H. Jarck	*July*	24
Joseph Kapral	*June*	39
A. G. Lamplugh	*May*	53
Charles J. Lowen, Jr.	*Nov.*	42
Edward E. Lubischer	*July*	24
Bernard L. Mock	*Feb.*	24
Victor K. Muzik	*Aug.*	14
Samuel Niedelman	*Dec.*	22
Harold W. Peterson, Jr.	*Mar.*	85
André A. Priester	*Feb.*	24
Major Richard R. Sheak	*Dec.*	22
Paul D. Smith	*Feb.*	24
Robert K. Souter	*Feb.*	24
William B. Stout	*May*	53
Paul G. Weiller	*Feb.*	25
Baldwin M. Woods	*Dec.*	23
NICOLA, R. N. Operational Digital Techniques for Special Purpose Computers	*Mar.*	78
O'MALLEY, JAMES A., JR., W. Z. STEPNIESKI, AND JOSEPH STUART III. VTOL-STOL Aircraft (A Compendium)—Part II	*Aug.*	44
Operations—		
Aircraft Noise as It Relates to the Airport Neighbor, Vice-Adm. Charles E. Rosendahl, USN (Ret.)	*June*	71
A Graphical Method for Determining the Aerodynamic and Economic Characteristics of Turboprop Air-Line Transport Systems, Ralph W. Allen	*Dec.*	55
Passenger Air-Line Economics, Lloyd B. Aschenbeck	*Dec.*	39
Pilot, Instruments, Controls, Gilbert L. Roth	*Sept.*	66

	Month	Page
PETROFF, A. N., EARL R. HINZ, AND WALTER TYDON. VTOL-STOL Aircraft (A Compendium) Part I	*July*	28
PINKEL, I. IRVING. Crash-Fire Research with Jet Aircraft	*Jan.*	53
RASMUSSEN, COMDR. A. L., USN. The New Naval Aviation Safety Program	*Aug.*	28
RASPET, AUGUST, JOSEPH J. CORNISH III, AND GLENN D. BRYANT. Delay of the Stall by Suction Through Distributed Perforations	*Aug.*	32
REGIER, ARTHUR A. Noise, Vibration, and Aircraft Structures	*Aug.*	56
REMPT, HENRY, AND M. J. CRONIN. The Impact of Electronic Equipment on Electric Generator Design and Aircraft Power Plants	*May*	87
Research—		
Crash Fire Prevention—Research to Flight Test, E. R. Zeek and I. J. Hammill	*July*	40
Crash Fire Research with Jet Aircraft, I. Irving Pinkel	*Jan.*	53
Project VANGUARD—The International Geophysical Year Earth Satellite, Rear Adm. F. R. Furth, USN (Ret.)	*Mar.*	55
Recent Developments in Braking of High-Speed Test Vehicles, Claude A. Brosterhous and Hugh B. Thompson	*Dec.*	26
RETHORST, SCOTT. Lift on a Wing in a Propeller Slipstream as Related to Low-Speed Flight	*Oct.*	42
Rockets & Missiles—		
Accessory Drive Turbines for Aircraft and Missiles, O. E. Baljé	*Mar.*	60
Economics of Rocket-Propelled Airplanes—Part I, Robert Cornog	*Sept.*	30
Economics of Rocket-Propelled Airplanes—Part II, Robert Cornog	*Oct.*	49
Growing a Reliable Missile, Richard C. Carhart	*Feb.*	28
Guided-Missile Propulsion, T. J. Keating	*June*	67
Rocket and Satellite Studies During the IGY, Joseph Kaplan	*Apr.*	64
Some Principles of Missile Guidance, Col. Richard C. Gibson, USAF	*May*	70
ROSENDAHL, VICE-ADM. CHARLES E., USN (RET.). Aircraft Noise as It Relates to the Airport Neighbor	*June*	71
Rotating Wing Aircraft—		
Helicopter Flight Trainer, Luis de Florez and E. K. Smith	*May*	114
ROTH, GILBERT L. Pilot, Instruments, Controls	*Sept.*	66
ROTHROCK, H. I. Navy Requirements for Air Navigational Aids, Communications Facilities, and Air Traffic Control, 1955–1975	*May*	82
RUSSEL, GEORGE M. Air Safety Engineering	*Feb.*	54
Safety—		
Air Safety, Otto E. Kirchner	*Feb.*	48
Air Safety Engineering, George M. Russel	*Feb.*	54
Aircraft Accident Investigation, Group Capt. R. C. Davis, RCAF	*Feb.*	37
All-Weather Flight Concern of the Pilot and Weather Forecaster, James K. Thompson	*July*	63
Crash Fire Prevention—Research to Flight Test, E. R. Zeek and I. J. Hammill	*July*	40
Crash Fire Research with Jet Aircraft, I. Irving Pinkel	*Jan.*	53
The In-Flight Collision Problem, J. Q. Brantley, Jr.	*July*	45
The New Naval Aviation Safety Program, Comdr. A. L. Rasmussen, USN	*Aug.*	28
Safety and Economic Aspects of Flight Simulators, A. F. Bonnalie	*Oct.*	71
Vertical Scanning Air-Borne Radar for Reducing Hazards of Aircraft Icing and Ground Collisions, Louis J. Battan	*Dec.*	52
SANT ANGELO, M. A., AND C. F. FRAGOLA. Integrated Flight Equipment System with Primary Emphasis on Instrumentation and Controls	*May*	62
Satellites—		
Project VANGUARD—The International Geophysical Year Earth Satellite, Rear Adm. F. R. Furth, USN (Ret.)	*Mar.*	55
Rocket and Satellite Studies During the IGY, Joseph Kaplan	*Apr.*	64
Satellites, Jorgen Jensen	*Sept.*	44
SCHMITT, ALFRED F. Dynamic Buckling Tests of Aluminum Shells	*Sept.*	54
SEDGWICK, THOMAS A., AND HARRY DRELL. Induction System Selection	*Nov.*	67
SLATER, J. M., AND D. B. DUNCAN. Inertial Navigation	*Jan.*	49
SMITH, E. K., AND LUIS DE FLOREZ. Helicopter Flight Trainer	*May*	114
STAHL, L. L. The Planning of Systems and Products for the Military Services	*June*	63
STEPNIEWSKI, W. Z., JOSEPH STUART III, AND JAMES A. O'MALLEY, JR. VTOL-STOL Aircraft (A Compendium)—Part II	*Aug.*	44
STEVER, H. GUYFORD. Electronics in Aviation (*Editorial*)	*May*	57
STROK, LT. COL. MICHAEL J., USA. STOL-VTOL Aircraft in the Air Mobile Army	*Nov.*	81
Structures—		
The Application of Nondestructive Testing by a Manufacturer of Military Aircraft, W. J. Maloney, Jr.	*Apr.*	76
Dynamic Buckling Tests of Aluminum Shells, Alfred F. Schmitt	*Sept.*	54
Experiment and Theory in the Investigation of the Behavior of Structures at High Temperatures, N. J. Hoff	*Feb.*	39
Materials and Fabrication Techniques for Structural Heat-Resistant Plastic Sandwiches, Norman E. Wahl	*Feb.*	34
Noise, Vibration, and Aircraft Structures, Arthur A. Regier	*Aug.*	56
A Re-Evaluation of Some Air-Frame Thermal Problems, Norris F. Dow	*Nov.*	61
The Structural Damping of Titanium at Elevated Temperature, H. F. Hunter	*Aug.*	18
Techniques and Problems in Testing Structures at Elevated Temperatures, Lewis H. Abraham	*Nov.*	56
Thermal Stresses and Deformations in Beams, Samuel Levy	*Oct.*	62
Unique Structural Problems in Supersonic Aircraft Design, F. P. Mitchell	*Jan.*	34
STUART, JOSEPH, III, W. Z. STEPNIEWSKI, AND JAMES A. O'MALLEY, JR. VTOL-STOL Aircraft (A Compendium)—Part II	*Aug.*	44

	Month	Page
THOMPSON, HUGH B., AND CLAUDE A. BROSTERHOUS. Recent Developments in Braking of High-Speed Test Vehicles	*Dec.*	26
THOMPSON, JAMES K. All-Weather Flight Concern of the Pilot and Weather Forecaster	*July*	63
TYDON, WALTER, EARL R. HINZ, AND A. N. PETROFF. VTOL-STOL Aircraft (A Compendium) Part I	*July*	28
VAN DRIEST, E. R. The Problem of Aerodynamic Heating	*Oct.*	26
VTOL & STOL Aircraft—		
Lift on a Wing in a Propeller Slipstream as Related to Low-Speed Flight, Scott Rethorst	*Oct.*	42
Problems in the Design of Propeller-Driven Vertical Take-Off Transport Airplanes, M. O. McKinney, R. E. Kuhn, and J. B. Hammack	*Apr.*	68
STOL Airplanes—A New Approach to Air Transport, R. A. Darby	*Mar.*	48
STOL-VTOL Aircraft in the Air Mobile Army, Lt. Col. Michael J. Strok, USA	*Nov.*	81
VTOL-STOL Aircraft (A Compendium)—Part I, Earl R. Hinz, Walter Tydon, and A. N. Petroff	*July*	28
VTOL-STOL Aircraft (A Compendium)—Part II, W. Z. Stepniewski, Joseph Stuart III, and James A. O'Malley, Jr.	*Aug.*	44
WAHL, NORMAN E. Materials and Fabrication Techniques for Structural Heat-Resistant Plastic Sandwiches	*Feb.*	34
WELLMAN, LT. COL. ROY J., USAF. The Turbine-Propeller Combination in the Air Force	*Aug.*	40
WELSH, JAMES P. Cooling Procedures Necessary to Avionic Reliability	*May*	110
WHITCOMB, RICHARD T. Zero-Lift-Drag Characteristics of Wing-Body Combinations at Transonic Speeds	*June*	42
WILSON, R. E., AND H. H. KURZWEG. Experimental Hyperballistics	*Dec.*	32
Wind Tunnels—		
Experimental Hyperballistics, H. H. Kurzweg and R. E. Wilson	*Dec.*	32
WITHINGTON, HOLDEN W. Silencing the Jet Aircraft	*Apr.*	56
WRIGLEY, W., C. S. DRAPER, AND L. R. GROHE. The Floating Integrating Gyro and Its Application to Geometrical Stabilization Problems on Moving Bases	*June*	46
ZEEK, E. R., AND I. J. HAMMILL. Crash Fire Prevention—Research to Flight Test	*July*	40
ZUCROW, M. J. The Problems of the Turbojet Engine as a Propulsion Engine for Supersonic Flight	*Dec.*	44

IAS Preprints

Preprints of CAI-IAS International Meeting Papers Currently Available

No.		Member Price	Non-member Price
658	RCAF Test and Development—Owen B. Philp.	$0.35	$0.75
657	The Technology of Guided Missiles and Its Effect on Industry—R. D. Richmond and J. F. Perrier.	0.50	0.85
656	A Method of Evaluating Jet-Propulsion-System Components in Terms of Missile Performance—Roger W. Luidens and Richard J. Weber.	0.35	0.75
655	The Airport and Airways Surveillance Radar for Canadian Air Traffic Control—B. I. McCaffrey.	0.50	0.85
654	A Survey of the Advantages of Transistors in Airborne Electronic Equipment—E. F. Johnson.	$0.35	$0.75
653	Operational Use of TACAN—Murray Block.	0.35	0.75
652	Applications of Ultrasonics in Aircraft—Charles P. Albertson and Philip Melara.	0.35	0.75
651	Quality Control Policy in the Royal Canadian Air Force—Robert McMillan.	0.35	0.75
650	The Canadian Test Flying Scene—D. H. Rogers.	0.35	0.75

Order by number from:

Preprint Dept., IAS, 2 E. 64th St., New York 21, N.Y.

ATTENTION

Aircraft Parts and Equipment Manufacturers

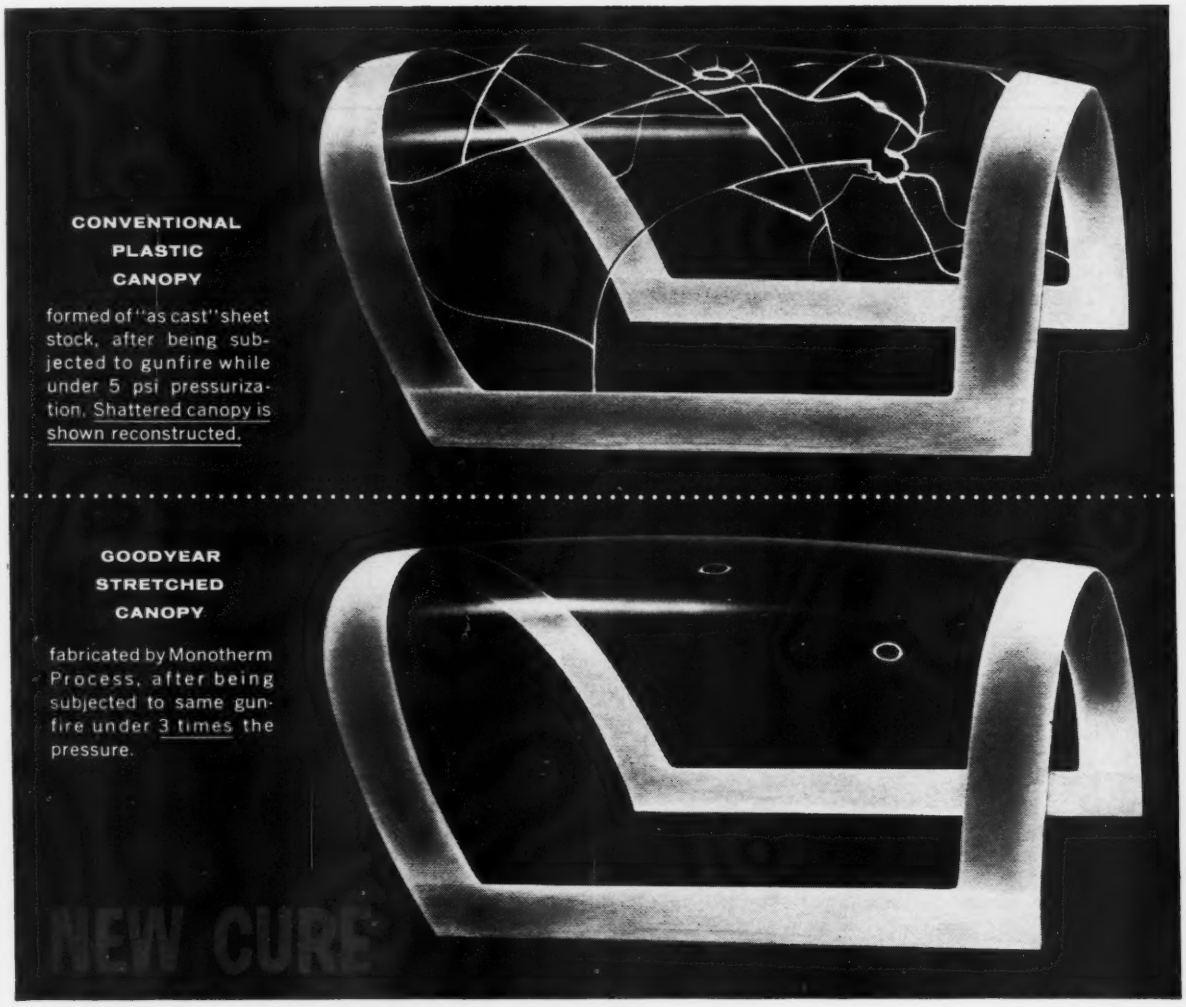
ORDER SPACE NOW
in the
1957 AERONAUTICAL ENGINEERING CATALOG

7,000 distribution in March, 1957, to buyers and buying engineers in aircraft and missile plants . . . aircraft engine plants . . . Air Force and Navy research and operational projects . . . NACA . . . private and industrial research laboratories and wind tunnels . . . major airlines.

Deadline for Advertising Copy—December 17, 1956
Deadline for Inserts—January 15, 1957

Write today for complete details and advertising rates

AERONAUTICAL ENGINEERING CATALOG
Published by:
INSTITUTE OF THE AERONAUTICAL SCIENCES
2 East 64th Street • New York 21, N.Y.


CONVENTIONAL PLASTIC CANOPY
formed of "as cast" sheet stock, after being subjected to gunfire while under 5 psi pressurization. Shattered canopy is shown reconstructed.
GOODYEAR STRETCHED CANOPY
fabricated by Monotherm Process, after being subjected to same gunfire under 3 times the pressure.
NEW CURE

FOR OLD HEADACHES in a jet's headgear

Some time ago, the National Bureau of Standards uncovered a curious fact concerning the nature of acrylic plastic: stretch it under heat and its needle-like molecules tend to lie down and flatten out, making the material much tougher.

To Goodyear Aircraft, this phenomenon seemed to be the clue to solving the long-standing problems of shattering—and crazing due to stresses and solvents—in aircraft cockpit canopies.

But there was a hitch. Plastic has a "memory." Heat it once to stretch it—but heat it again to form it into the desired shape, and its molecules tend to fight their way back to their weaker original arrangement.

Goodyear Aircraft solved it by developing an exclusive Monotherm Process which achieves maximum stretch *and simultaneously forms the plastic in a single operation.*

Already, the weight-savings and toughness resulting from this technique have moved the military and leading plane producers to place contracts with Goodyear Aircraft specifying stretched canopies formed by the Monotherm Process.

It is another example of plastics pioneering by Goodyear Aircraft, which—as first to stretch-form a full-size canopy—once again establishes the criteria for future progress in an important field. For information on these plastics facilities and skills, write:

Goodyear Aircraft Corporation
Dept. 931FX, Akron 15, Ohio

S-T-R-E-T-C-H-E-D PLASTICS by

GOODYEAR AIRCRAFT

Plants in Akron, Ohio, and Litchfield Park, Arizona

Monotherm—T.M. Goodyear Aircraft Corporation, Akron 15, Ohio

PUBLICATION STAFF

EDITOR: Welman A. Shrader
MANAGING EDITOR: Rita J. Turino
ASSISTANT EDITOR: Allan Bernhardt
REVIEWS EDITOR: Irene W. Bogolubsky
BOOK REVIEWS EDITOR: John J. Glennon
EDITORIAL ASSISTANTS: Helen S. Goldman
Justine C. Pruyn

TECHNICAL ADVISERS
W. R. Sears • Robert R. Dexter • S. Paul Johnston

ADVERTISING MANAGER: Joseph P. Ryan
BUSINESS MANAGER: Hugh C. Judge
ADVERTISING PRODUCTION MGR.: R. N. Lipner

EDITORIAL ADVISORY COMMITTEES

Aircraft Design, Structures, & Materials

A. Francis Arcier
Wellwood E. Beall
William B. Bergen
Fred N. Dickerman
Robert L. Hall
Edward H. Heinemann
Harold D. Hoekstra
C. L. Johnson
Alexander Kartveli
Kendall Perkins
Richard L. Schleicher
Edgar Schmued
Igor I. Sikorsky
Ernest G. Stout
Kirby F. Thornton
Walter Tydon

Flight Propulsion

George W. Brady
Dimitrius Gerdan
Leonard S. Hobbs
R. P. Kroon
Everard M. Lester
W. G. Lundquist
Abe Silverstein
Philip B. Taylor
E. S. Thompson
Raymond W. Young

Instruments

Preston R. Bassett
Victor E. Carbonara
Charles H. Colvin
Frank R. Cook
Richard M. Mock
Walter H. Skidmore
R. C. Sylvander

Air Transport & Operations

Charles Froesch
J. A. Herlihy
John C. Leslie
William Littlewood
R. W. Rummel
R. Dixon Speas

Electronics

K. C. Black
Bruce G. Eaton, Jr.
Richard B. Hubbard
David S. Little
Frank Mansur
John Margosian
P. C. Sandretto

Specialties

Robert J. Benford, M.D.
Melvin N. Gough
Jerome Lederer

SUBSCRIPTION RATES

Aeronautical Engineering Review: United States and possessions, 1 year, $3.00; single copies, $0.50. Foreign countries including Canada (American Currency Rates), 1 year, $3.50; single copies, $0.50.

Entered as second-class matter at the Post Office, Easton, Pa., April 29, 1942. Acceptance for mailing at a Special Rate of Postage as provided for in the Act of August 24, 1912.

Publication Office: 20th & Northampton Streets, Easton, Pa.

Editorial Office: 2 East 64th Street, New York 21, N.Y. Notices of change of address should be sent to the Institute at least 30 days prior to actual change of address.

Statements and opinions expressed in the Aeronautical Engineering Review are to be understood as individual expressions and not those of the Institute.

© Copyright, 1956, by the Institute of the Aeronautical Sciences, Inc.

SUPERSONIC
HYPERSONIC

research
scientists
engineers

What's beyond?—Here, at the West's largest jet engine research and development center, Marquardt's newly created research division is already probing into the most advanced concepts of supersonic and hypersonic flight, researching new chemical fuels and nuclear energy, integrating advanced propulsion schemes with aerodynamic requirements.

To continue this research, effectively, we need additional qualified research scientists and engineers in supersonic and hypersonic flight and related fields. We need explorers looking for a future in an atmosphere of individual professional development and continued academic training. We need men who are right now saying to themselves, "What's beyond?".

marquardt AIRCRAFT CO.

Call or write today.

MARQUARDT AIRCRAFT COMPANY, Research Division

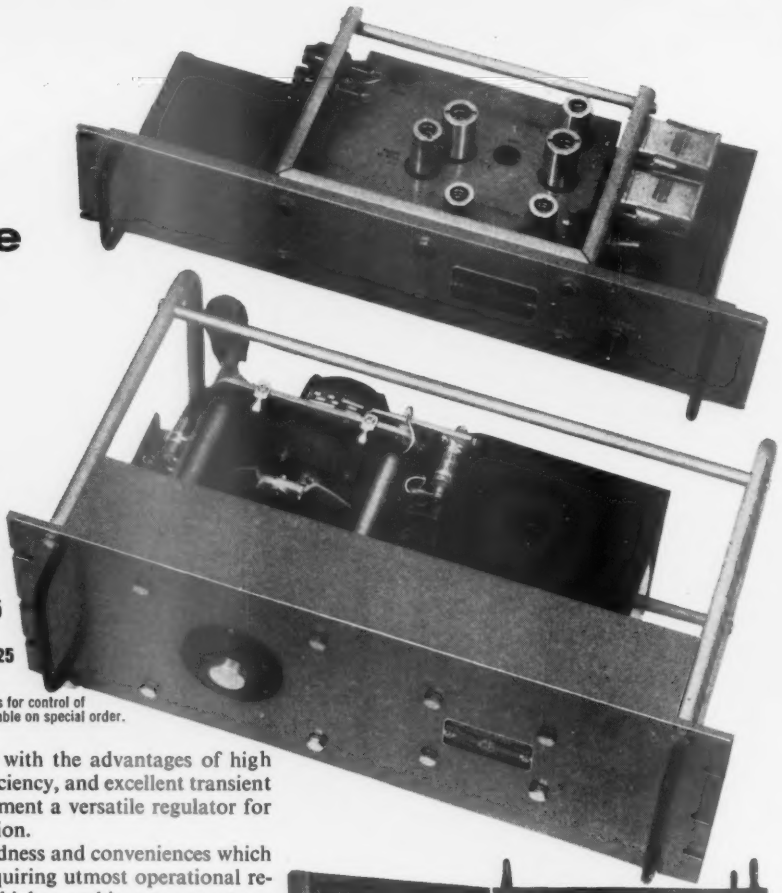
Attention: John A. Drake, Director of Research
16553 Saticoy Street, Van Nuys, Calif. • STate 5-8361

New
Militarized
Line-Voltage Regulator

6 KVA Power Capacity

Holds Output Constant within ±0.25%

Fast 10v-per-sec Response



Type 1570-ALS15
Automatic Line-Voltage Regulator
for 115v, 50-60 cycle service . . . **$625**
(Price for quantities on request)

230v models and units for control of 400-cycle power available on special order.

High power handling capacity coupled with the advantages of high accuracy, no waveform distortion, high efficiency, and excellent transient response make this servo-controlled equipment a versatile regulator for laboratory, industrial, or military application.

This new unit features mechanical ruggedness and conveniences which recommend it to many industrial users requiring utmost operational reliability. For example: it can operate at higher ambient temperatures (55°C) without derating; all tubes and components are military types meeting stringent performance standards; the complete hermetic sealing of transformers, capacitors and other components provides maximum protection in corrosive atmospheres.

In addition to meeting military environmental requirements, the unit is designed with particular emphasis on flexibility and accessibility. The electronic circuitry for sampling the output voltage and controlling the servo motor is in a separate package; this "control" section can be used with various combinations of Variacs and "buck-or-boost" transformers in a second package to make possible regulators with various power ratings. This feature also simplifies servicing, since only one type control circuit, interchangeable in all units, is involved. When service of the electronic circuitry is required, only one unit need be removed; the larger unit with all its power wiring can stay in service and will supply uninterrupted power under manual control.

Advanced mechanical design makes this a convenient unit to install and maintain. A complete circuit diagram is silk-screened on the inside of the bottom cover plate; when removed, this plate exposes *all* wiring. Every tube may be replaced directly, and removal of a single dust cover exposes all other components. Component values and circuit designations are etched on the mounting board for rapid, convenient identification. These are but a few of the special features built into this design.

As is often the case, care and consideration given important details make the first-class instrument. Where maximum electrical and mechanical reliability is needed, this Regulator will do the job.

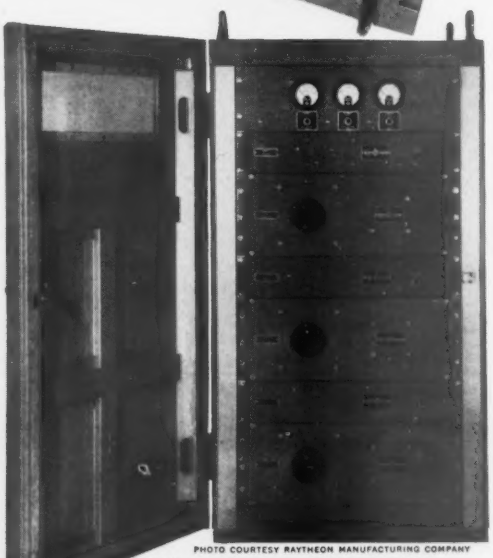


PHOTO COURTESY RAYTHEON MANUFACTURING COMPANY

Built Into Continental Radar Network

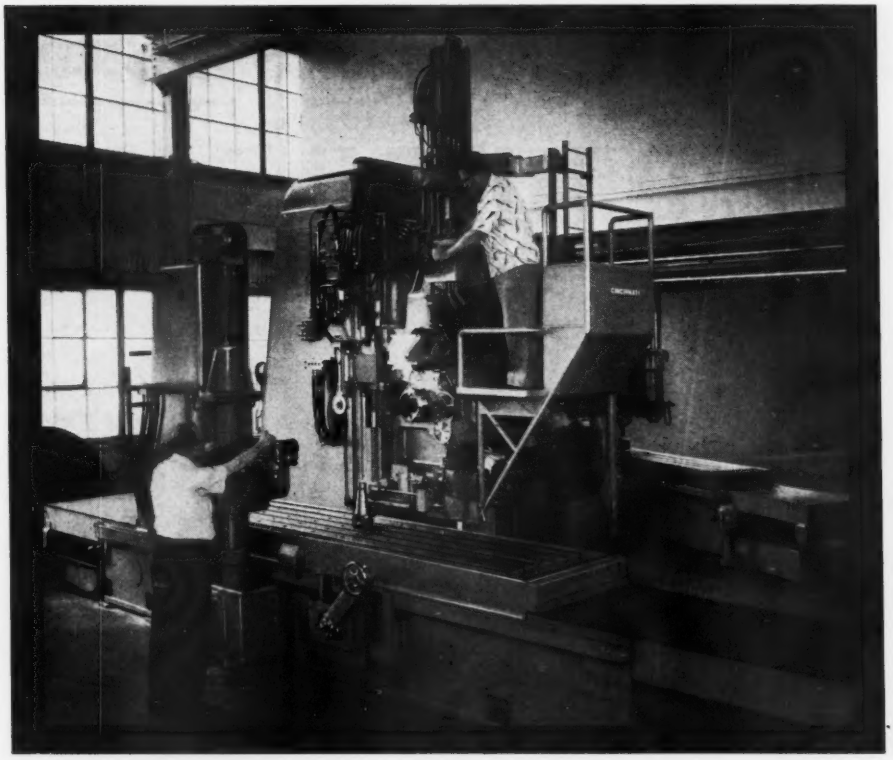
G-R Automatic Line-Voltage Regulators control 18-kva, 3-phase power for reliable 24-hour a day operation

WRITE FOR COMPLETE INFORMATION

GENERAL RADIO Company

275 Massachusetts Avenue, Cambridge 39, Mass., U.S.A.

Broad Avenue at Linden, Ridgefield, N. J. **NEW YORK AREA** 920 S. Michigan Ave. **CHICAGO 5**
1150 York Road, Abington, Pa. **PHILADELPHIA**
8055 13th St., Silver Spring, Md. **WASHINGTON, D. C.** 1000 N. Seward St. **LOS ANGELES 38**

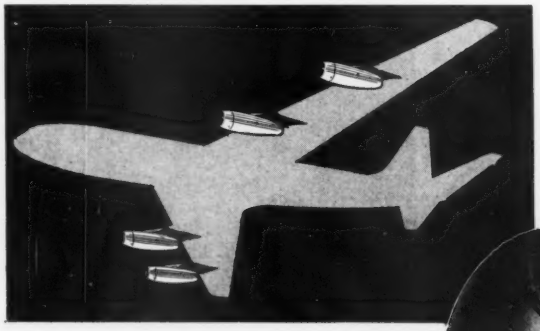


HORIZONTAL HYDROTEL – PART OF
ROHR'S MULTI-MILLION DOLLAR TOOL KIT

This 36" x 120" Cincinnati Horizontal Hydrotel shown above employs three different tracers, a 360-degree tracer, a depth control tracer for contour milling, and a rise and fall tracer. It assures extreme accuracy for very special Rohr jobs.

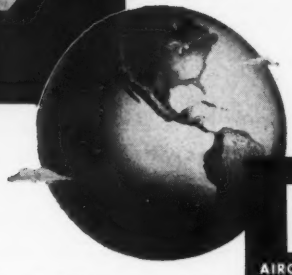
With this and hundreds of other heavy, modern manufacturing machines, Rohr produces over 30,000 different aircraft parts for builders of many of America's leading commercial and military planes. This is, of course, in addition to Rohr's fame as the world's largest producer of ready-to-install Power Packages.

For full production facilities – for design and engineering know-how, look to Rohr to build more into the aircraft parts you need.



In addition to the Boeing 707 Rohr builds Power Packages for many other commercial and military planes which have made Rohr famous as the

WORLD'S LARGEST PRODUCER OF READY-TO-INSTALL POWER PACKAGES FOR AIRPLANES

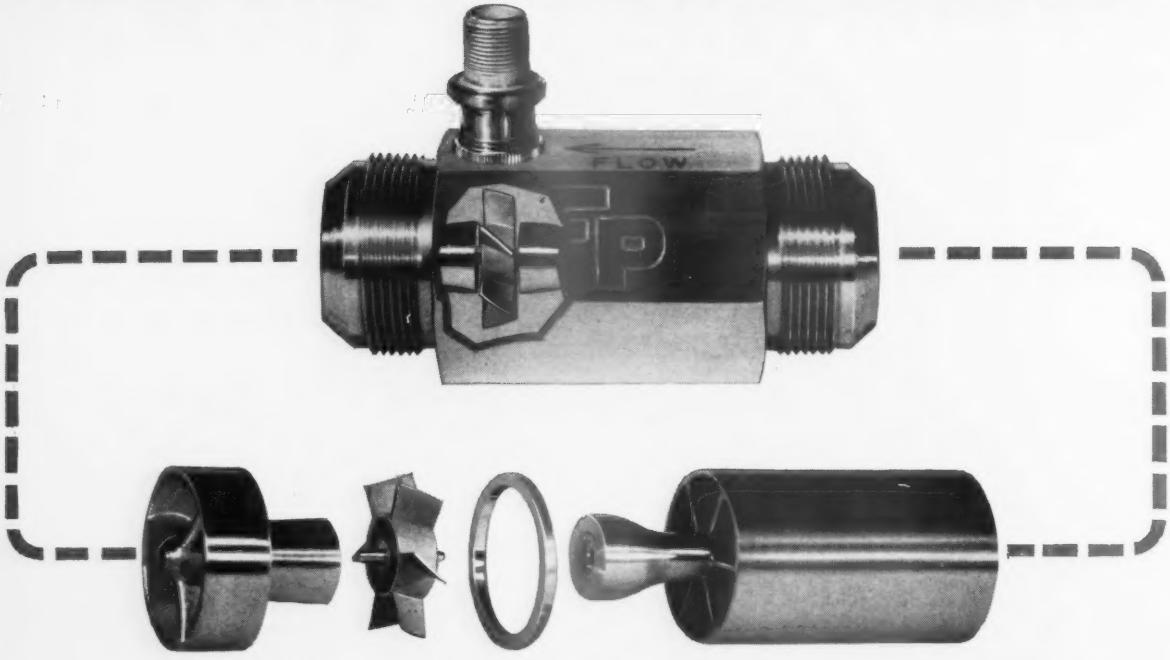


ROHR
AIRCRAFT CORPORATION

EXCELLENT CAREER OPENINGS NOW FOR ENGINEERS AND SKILLED TECHNICIANS

Plants in Chula Vista and Riverside, California; Winder, Georgia; Auburn, Washington

The big difference is inside the NEW F&P TURBINE METER



NOW AVAILABLE TO YOU is the new F&P Turbine Meter—made to the same high standards that has made Fischer & Porter a world leader in flow measurement know-how.

Also from F&P you can secure a complete line of electronic digital and analog readout instruments, associated data handling instrumentation and unsurpassed calibration facilities—making the application of F&P Turbine Meter practical—dependable and easy to integrate into systems operation.

Inherent precision accuracy.

Unaffected by piping or orientation.

Easily disassembled and re-assembled with no shift in calibration.

Wide-linear flow range.

Digital output proportional to flow.

Interchangeable calibration factors within size.

Low inertia for excellent transient response.

Write today for complete information on the F&P Turbine Meter. Test it in your own processes and you'll agree that here is a better, sturdier, less costly turbine meter than ever before available. Write to Fischer & Porter Co., 2026 County Line Road, Hatboro, Penna.

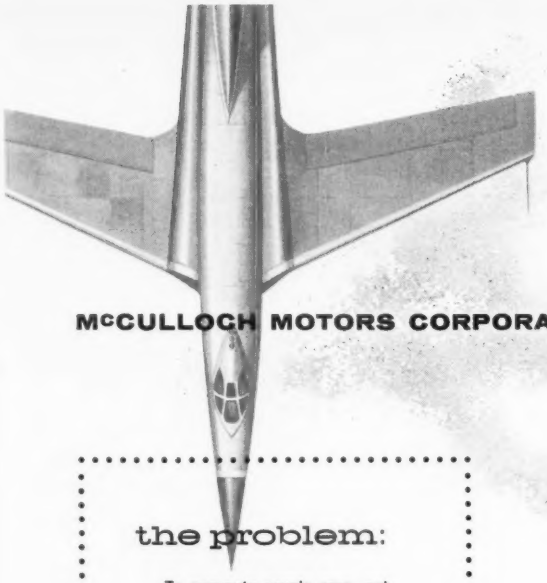
Unexcelled calibration facilities

The Colburn Memorial Flow Laboratory at Fischer & Porter, the finest and most modern of its kind in the world, provides the basic standards for flow measurement of all F&P flow meters.

FP FISCHER & PORTER CO. Hatboro, Pa.

COMPLETE PROCESS INSTRUMENTATION

LA1143



McCULLOCH MOTORS CORPORATION

saved 2899 engineering manhours with a Bendix G-15 computer!

the problem:

To compute nozzle area, net thrust and fuel consumption for a new turbine design. 729 sets of answers were required, due to problem variables.

solution:

This problem was essentially unsolvable by conventional methods. The 729 sets of answers would require 2916 manhours on the slide rule, or 10 valuable engineers or mathematicians working for 36 days.

Including programming and check-out time, only 17 hours were required to obtain the 729 sets of answers when McCulloch turned the problem over to the Bendix G-15 General Purpose Digital Computer. **The solution was obtained by one man** and the chance for human error was greatly reduced. But most important, **the engineering time saved was 2899 manhours**...171 times less than conventional methods. The same type of problem could be solved again in five hours.

New G-15 programming methods suit both the engineer with an occasional problem and the experienced programmer. The INTERCOM system can be learned in just a few hours. As a bonus, an inexpensive accessory adds digital differential analyzer capabilities to the talented G-15. The coupon will bring you further details on the G-15's ability to conserve scarce engineering manhours in a wide range of applications.

Bendix Computer

DIVISION of BENDIX AVIATION CORPORATION

OFFICES IN WASHINGTON, D.C., DALLAS, AND LOS ANGELES

Export Representatives
Computing Devices of Canada, P.O. Box 508, Ottawa 4, Ontario
Bendix International Division, 205 E. 42nd Street, New York 17, N.Y.

BENDIX COMPUTER DIVISION—BENDIX AVIATION CORPORATION
5630 ARBOR VITAE STREET, LOS ANGELES 45, CALIFORNIA

Please send me more details on your Model G-15 General Purpose Digital Computers.

NAME_____

TITLE_____

COMPANY_____

ADDRESS_____

DEPARTMENT OF TECHNOLOGY
BUFFALO AND ERIE COUNTY PUBLIC LIBRARY

Janitrol purge gas generators provide safe armorplate of gas for fuels in modern aircraft.

Janitrol Platular* heat exchangers in modular units, reduce weight and increase design freedom.

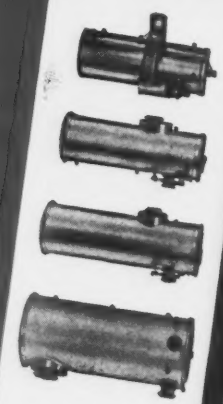
*T. M. Reg.

what's new in the Janitrol line

Janitrol standard couplings for compressor air ductwork save up to 40% in weight.

Janitrol hot fuel prime units help engines start in seconds and run free in minutes, from −65°F.

Janitrol pneumatic control valves for critical high pressure applications combine functions, save weight and space.

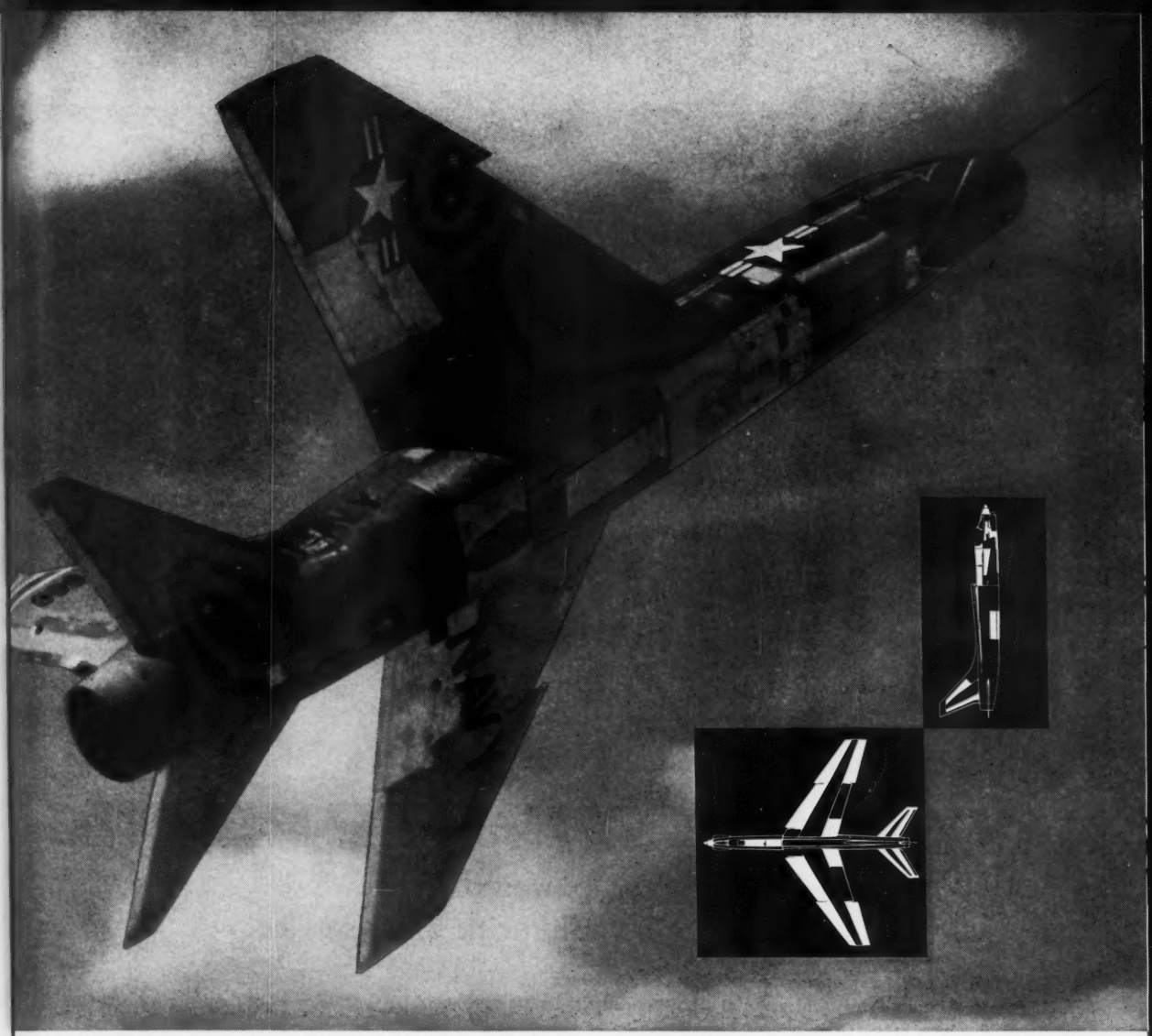


Janitrol combustion heaters continue to provide the last word in versatility, easy installation, and dependability.

Janitrol Aircraft Automotive Division,
Surface Combustion Corporation,
Columbus 16, Ohio

Janitrol®

DISTRICT ENGINEERING OFFICES: WASHINGTON, D.C., PHILADELPHIA, COLUMBUS, FT. WORTH, HOLLYWOOD



Weight-saving magnesium sheet (white areas) is used for leading edges, empennage, wheel doors and many other parts of F8U-1 Crusader.

25% of external skin on record-breaking F8U-1 made with magnesium

In Chance Vought's F8U-1 Crusader, fastest U.S. fighter by official record, many precious pounds are saved by using magnesium. Designers called for a total of 166 magnesium external skin parts—25% of the wing and fuselage surface area. 275 magnesium sand castings ranging in weight from a few ounces to thirteen lbs. were used inside the skin.

Weighing one fourth as much as steel and only two thirds as much as aluminum, magnesium gives you the best combination of strength and rigidity per pound. Its stiffness-to-weight ratio is the highest of any structural metal.

Magnesium permits clean, simplified designs—eliminates many stringers and detail parts. A selection of finishes provides remarkable protection against corrosion. Machinability is excellent, too. Fabrication, fitting and joining problems are always at a minimum.

Magnesium can help you make better designs for fuselage, wings and interior parts. Sheet, extrusions, and castings can be readily produced to meet your requirements. Call your local Dow sales office, or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Department MA363GG.

you can depend on DOW MAGNESIUM

DOW

NAVY FLIGHT SETS NEW RECORD

Allison Turbo-Prop-powered "Tradewind" opens new era in vital Pacific Fleet service

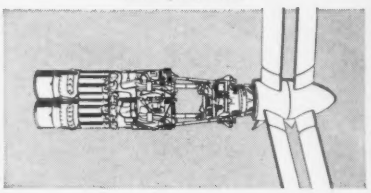
A few weeks ago the U.S. Navy opened a new chapter in aviation history when its giant aerial tanker – the Convair R3Y-1 Tradewind – set a new trans-pacific speed record for water-based aircraft. On its maiden round-trip flight from Alameda, California, to Keehi Lagoon, Honolulu, Air Transport Squadron TWO [VR-2] firmly established the Navy's long-standing belief in turbo-prop power as the jet age's most flexible and efficient power source. On its return flight the Tradewind covered the nearly 2,500 miles over water span in 6¾ hours, far surpassing the record on this route for this type aircraft.

Powered by four Allison twin power section turbo-prop engines driving contrarotating Aeroproducts Propellers, the Tradewind boasts nearly 24,000 horsepower—can lift its 80-ton weight from the water in 30 seconds, climb quickly to cruising altitude and cover more than 2,000 miles nonstop at speeds in excess of 350 miles per hour.

What makes this astounding aerial feat possible is the development of a whole new concept of powered flight—the culmination of 10 years of research by the Navy, Convair and Allison. It required the solving of one of the most complex engineering challenges in aviation history—perfecting a gas turbine engine of advanced design and mating it with a six-bladed contrarotating propeller.

The R3Y-1 Tradewind will refuel in flight eight jet fighters—*four at a time* —at speeds of more than 350 miles per hour. This new addition to the vast Pacific Fleet, the R3Y-1 will provide a vital service to our fast carrier task forces, further extending the range and striking power of the Navy's mighty air arm.

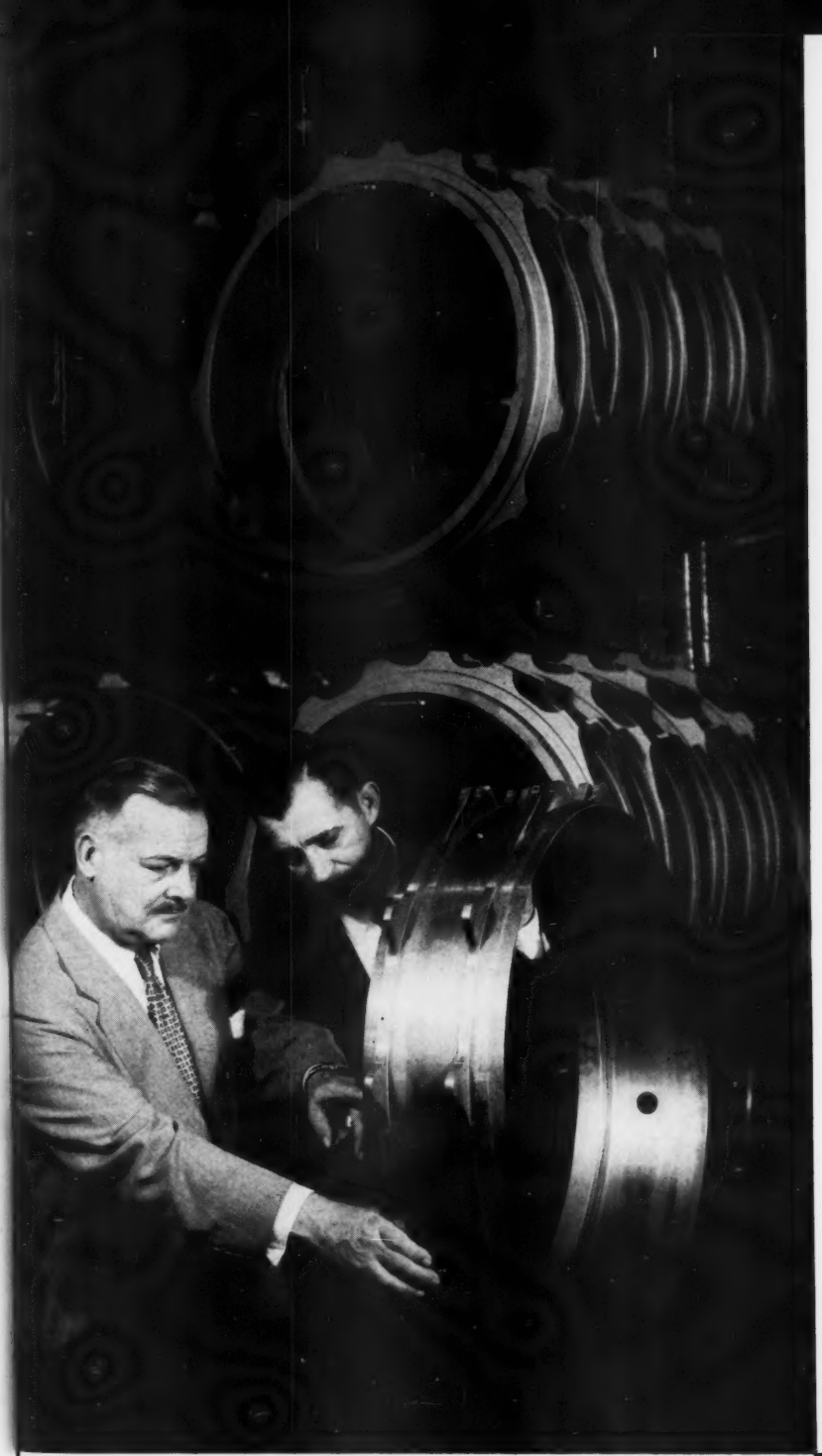
ALLISON DIVISION OF GENERAL MOTORS CORPORATION
Indianapolis, Indiana

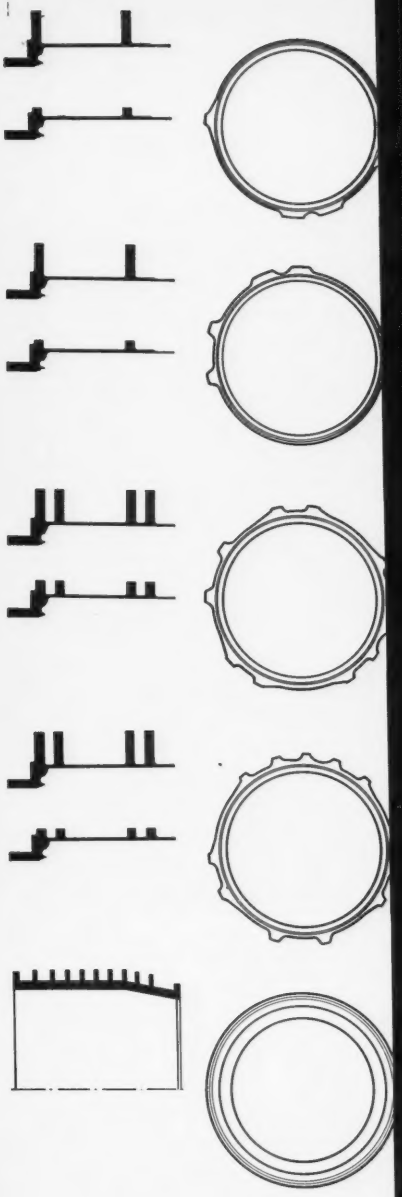


R3Y-1 demonstrates versatility of Turbo-Prop power in jet-age transportation

Record-breaking Navy R3Y-1 is powered by four T40 Allison Turbo-Prop engines like this—each having twin power sections driving contrarotating Aeroproducts Propellers. Both power sections in each engine give the R3Y-1 full power for rapid take-off and climb to cruising altitude. To gain best fuel economy for cruising, one power unit may be shut off entirely, allowing the other to operate at its most efficient setting. Either power section operates all six blades contrarotatively.

ALLISON
TURBO-PROP POWER
VERSATILE POWER FOR JET-AGE FLIGHT





Typical ring sections and profiles showing lug configurations in a smaller scale.

STAINLESS STATOR RINGS

One of Cameron's most interesting contributions to military and commercial air-power today is the production of forged, stainless steel, stator rings. Our unique processes make possible precision forgings with odd lug configurations, large diameters and a vastly superior grain structure. Shapes and sizes heretofore costly to produce as a forging are now sound economy at Cameron.

The study of specialized alloys to meet the extreme demands of today and to anticipate those of tomorrow parallels forging production and is a part of our progress.

Investigate these advantages — write or call . . . . .

Cameron

IRON WORKS, Inc.

SPECIAL PRODUCTS DEPARTMENT
P. O. Box 1212, Houston, Texas

35 ton bomber gets carrier shakedown

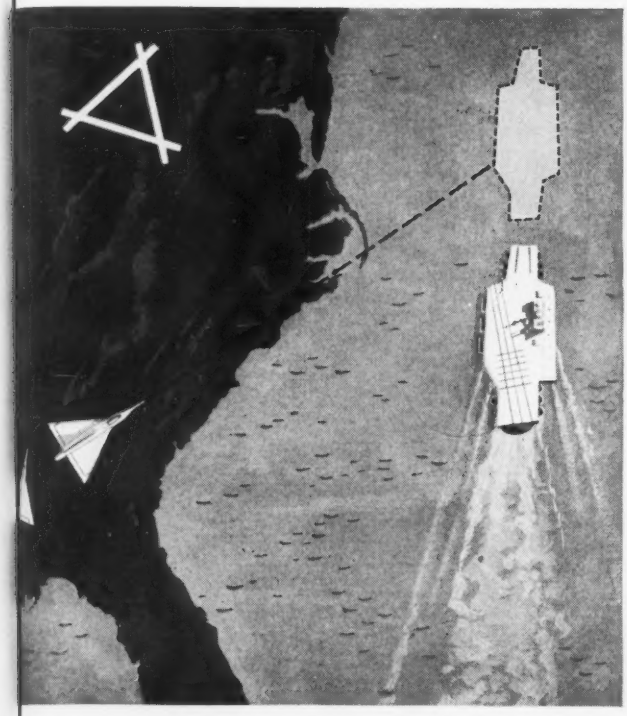
Largest and most powerful aircraft ever to operate from a carrier deck, the Douglas A3D Skywarrior has now completed landing and takeoff tests aboard the U. S. S. Forrestal—the Navy's mightiest carrier. Able to deliver the A-bomb, at speeds above 600 mph, Skywarrior is designed to extend our carrier's striking range beyond any point yet reached.

U. S. Navy's atom bomber, the Douglas A3D Skywarrior

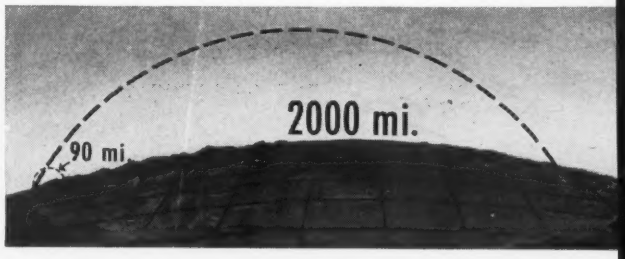
Continued advances in naval aircraft are meaningless without skilled fliers at the controls. If you are interested in a career as a Naval Aviator, drop a card today to *Nav. Cad., Washington 25, D. C.*

Depend on *DOUGLAS* First in Aviation

Here's why BENDIX SELF-CONTAINED NAVIGATIONAL COMPUTERS can master aircraft navigation problems anywhere

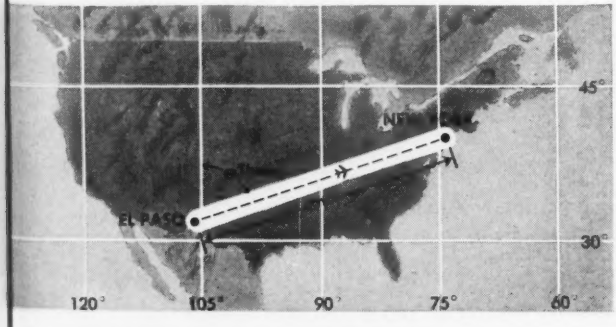


3 ALSO LATITUDE-LONGITUDE TYPE. Another basic type of Bendix Computer fixes destinations from coordinates. For rugged reliability, all designs are completely transistorized; presentation of information is by latest techniques, including cathode ray pictorial display.



1 BOTH FIXED AND MOVING TARGETS. Bendix Self-contained Navigational Computers will direct the course to any fixed target . . . or a lead collision course to any moving target . . . and will continuously indicate position with respect to earth, destination, or point of intercept.

4 FOR SHORT AND LONG RANGE. Effective operation of these self-contained Bendix units ranges from distances of less than 100 miles on up to 2000-mile flights. A big advantage of buying Bendix is that units can be tailored and packaged to meet any set of requirements.



2 RHO-THETA TYPE, IF DESIRED. Bendix experience is diversified and covers all types of computers—rho-theta, for example—for any desired method of navigation. So flexible are Bendix Computers that they can be built for *slaving to radio navigation aids* at the operator's choice.

5 GREAT-CIRCLE OR RHUMB-LINE NAVIGATION. Navigation around the world, *or over the poles*, by great circle or rhumb line, can be handled with equal facility and accuracy. A design feature of Bendix Computers is compactness and light weight. Some weigh as little as 12 lbs.

THE DESIGN AND MANUFACTURE of specialized navigational instruments, systems and components for aircraft have been our business for nearly four decades. Whatever your navigation problems might be, we'd welcome an opportunity to submit a proposal for your specific needs. ECLIPSE-PIONEER DIVISION, BENDIX AVIATION CORPORATION, TETERBORO, N. J.

West Coast Offices: 117 E. Providencia, Burbank, Calif.
Room 114, Administration Bldg., Boeing Field, Seattle 8, Wash.
Export Sales and Service: Bendix International Division, 205 E. 42nd St., New York 17, N.Y.

Eclipse-Pioneer
DIVISION

Bendix
AVIATION CORPORATION

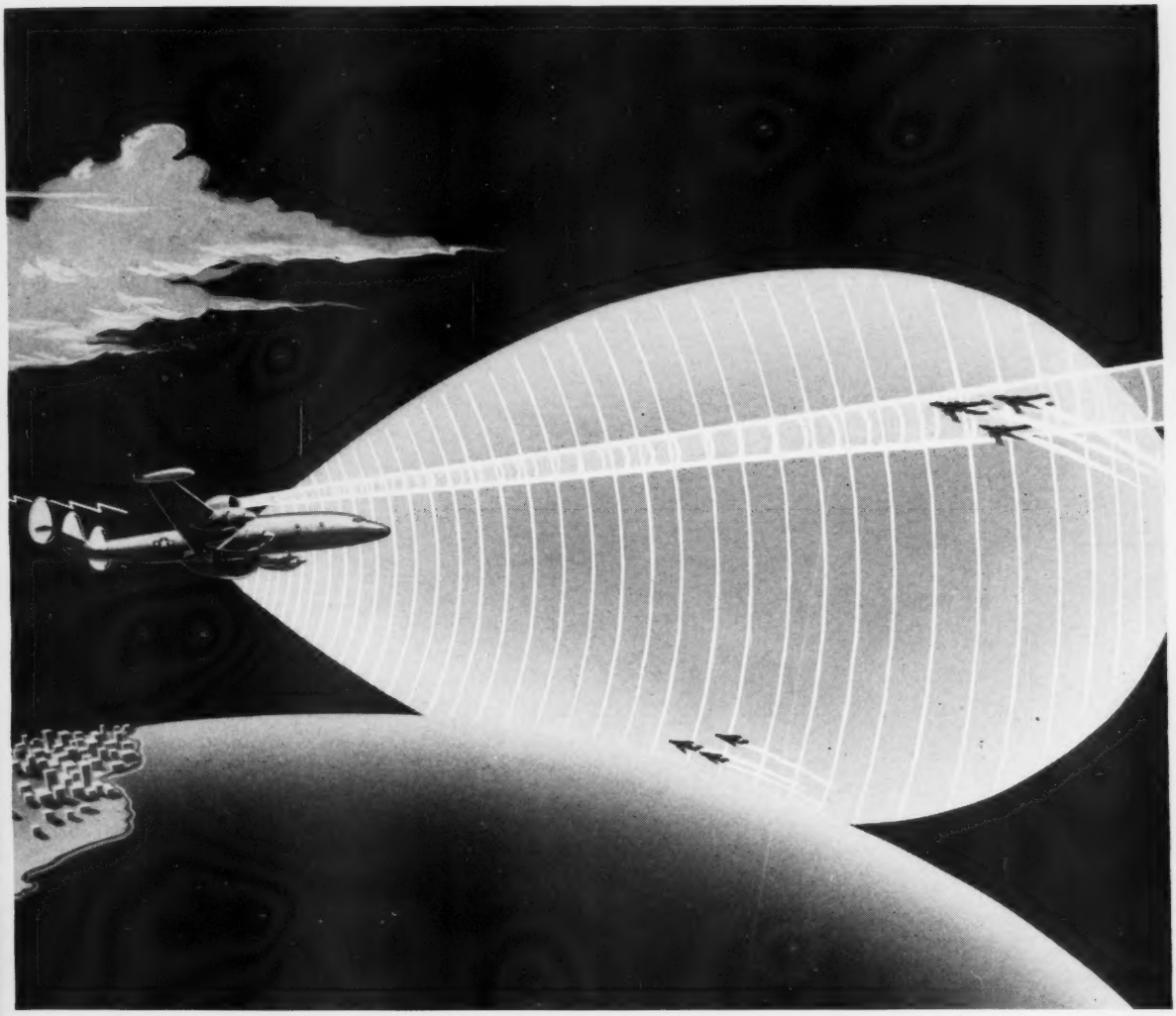
THE CORD HAS BEEN CUT

an has at last severed the tie that bound him to other Earth. *Gyroscopic stable platforms* and *inertial vigation systems* can now free him from all terrestial sources of information... In the outer regions, here the terms Up, Down, East and West are meanless, these fantastically accurate instruments compute sition, course, and attitude entirely without reference to maps based upon the earth's surface... Lear ha *pioneered* the design and production of inertial stabili zation and navigation systems. Today these device guide and stabilize man's most advanced missiles an aircraft. Tomorrow they will orient and control spacecraft yet to be developed.

LEAR

masters of master reference systems for all aircra

R INC., SANTA MONICA, CALIFORNIA



Nothing escapes this "see" plane...

It's a virtual seeing eye plane—this radar picket plane whose task it is to extend the searching eyes of ground radar stations. For radar beams travel in straight lines ...cannot bend to follow the horizon. With radome installations on top and bottom of the plane, both high level and low level intruders are under surveillance over a far greater area than is possible with earthbound radar. It's almost impossible for anything to escape this all-seeing eye!

These Lockheed Super Constellation radar picket planes must stay airborne for long periods of time under all weather conditions...and so are designed for durability and dependability. Lockheed relies on Shafer Aircraft Bearings, with their high reserve capacity for combined radial and thrust loads and integral self-alignment, to assure uninterrupted operation of these aerial radar outposts.

Shafer Aircraft Bearings are typical of the creative engineering inherent in the broad CHAIN Belt product line...of CHAIN Belt's ability to develop products and service to help you increase efficiency, reduce costs.

For information on how we can help you, call your local CHAIN Belt Field Sales Engineer or write CHAIN Belt Company, 4730 West Greenfield Avenue, Milwaukee 1, Wisconsin.

Shafer aircraft bearings

CHAIN BELT COMPANY

MILWAUKEE 1, WISCONSIN

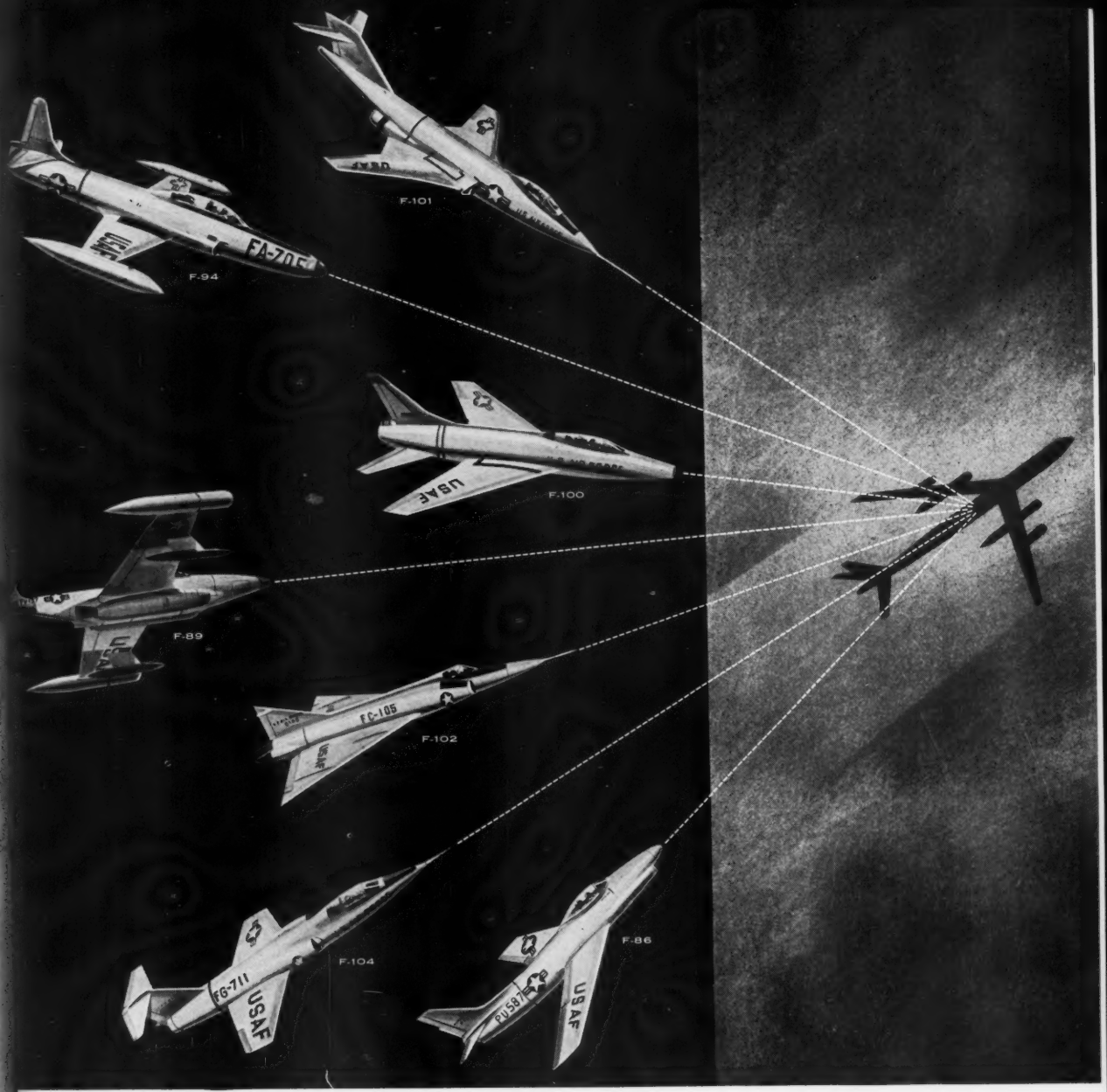
KAMAN HOK-1

The Helicopter You FLY LIKE A PLANE...

Pilots who have never been in a helicopter before are amazed at the ease with which the Kaman HOK-1 can be flown. Any pilot familiar with fixed wing aircraft can fly the HOK-1 and fly it well.

The **KAMAN** *Aircraft Corporation*

BLOOMFIELD, CONNECTICUT, U.S.A.



Fire control radar tells... / ***WHERE TO AIM WHEN TO FIRE!***

All-seeing radar pinpoints the target for these Air Force planes. Whatever armament they carry—guns, rockets or missiles—fire control radar tells them *where* and *when*. It provides the far-sighted vision necessary for modern long-range combat operations.

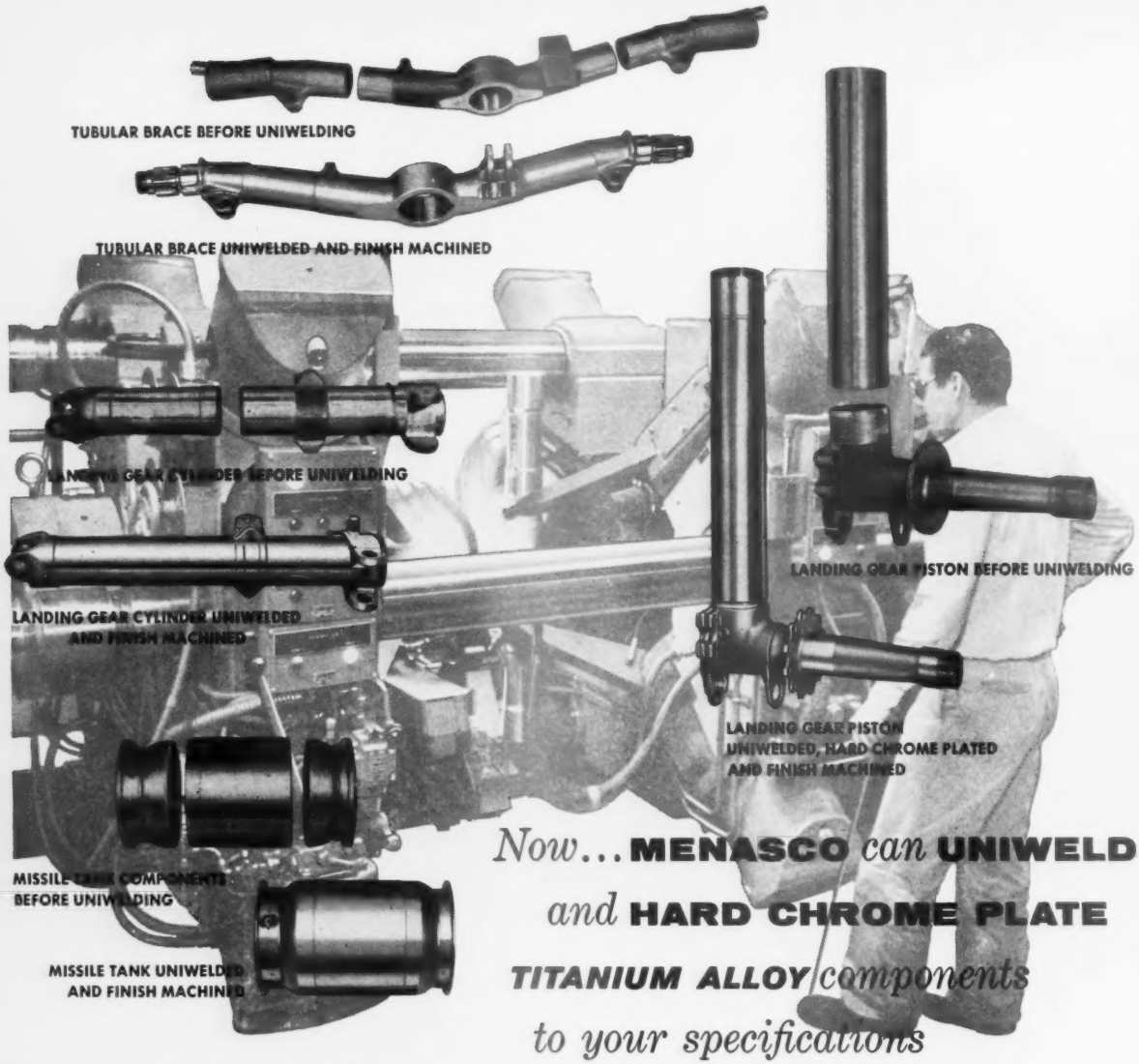
Today's modern fighter plane is an electronic wonder, with fire control radar-computer systems supplying a continuous flow of information about target position in terms of range and rate of closing.

RCA is a major supplier of airborne fire control equipment to the Armed Forces. It has produced, and in several instances developed, these systems for many of the latest aircraft. Some of these are illustrated above.

Defense Electronic Products

RADIO CORPORATION of AMERICA

Camden, N.J.


TUBULAR BRACE BEFORE UNIWELDING
TUBULAR BRACE UNIWELDED AND FINISH MACHINED
LANDING GEAR CYLINDER BEFORE UNIWELDING
LANDING GEAR CYLINDER UNIWELDED AND FINISH MACHINED
LANDING GEAR PISTON BEFORE UNIWELDING
LANDING GEAR PISTON UNIWELDED, HARD CHROME PLATED AND FINISH MACHINED
MISSILE TANK COMPONENTS BEFORE UNIWELDING
MISSILE TANK UNIWELDED AND FINISH MACHINED

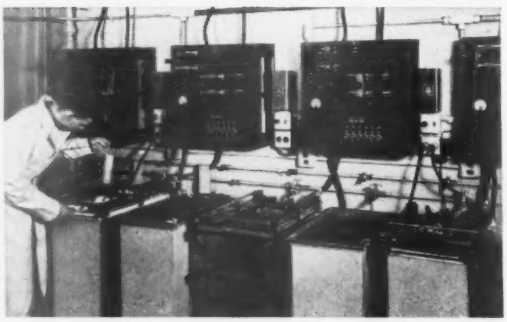
Now... **MENASCO** *can* **UNIWELD** *and* **HARD CHROME PLATE** ***TITANIUM ALLOY*** *components to your specifications*

Up to 40% weight reduction possible by the use of MENASCO's exclusive *Uniwelding* process which assures superior strength, greater consistency, and ductility in welds, *and*, excellent wear-resistance by the only proven method of hard chromium plating.

Illustrated are typical examples of what MENASCO can do with these two processes to fabricate titanium components for aircraft and missile applications.

Major aircraft manufacturers look to MENASCO for efficient engineering, product development and new fabricating techniques.

WHAT ARE YOUR REQUIREMENTS?

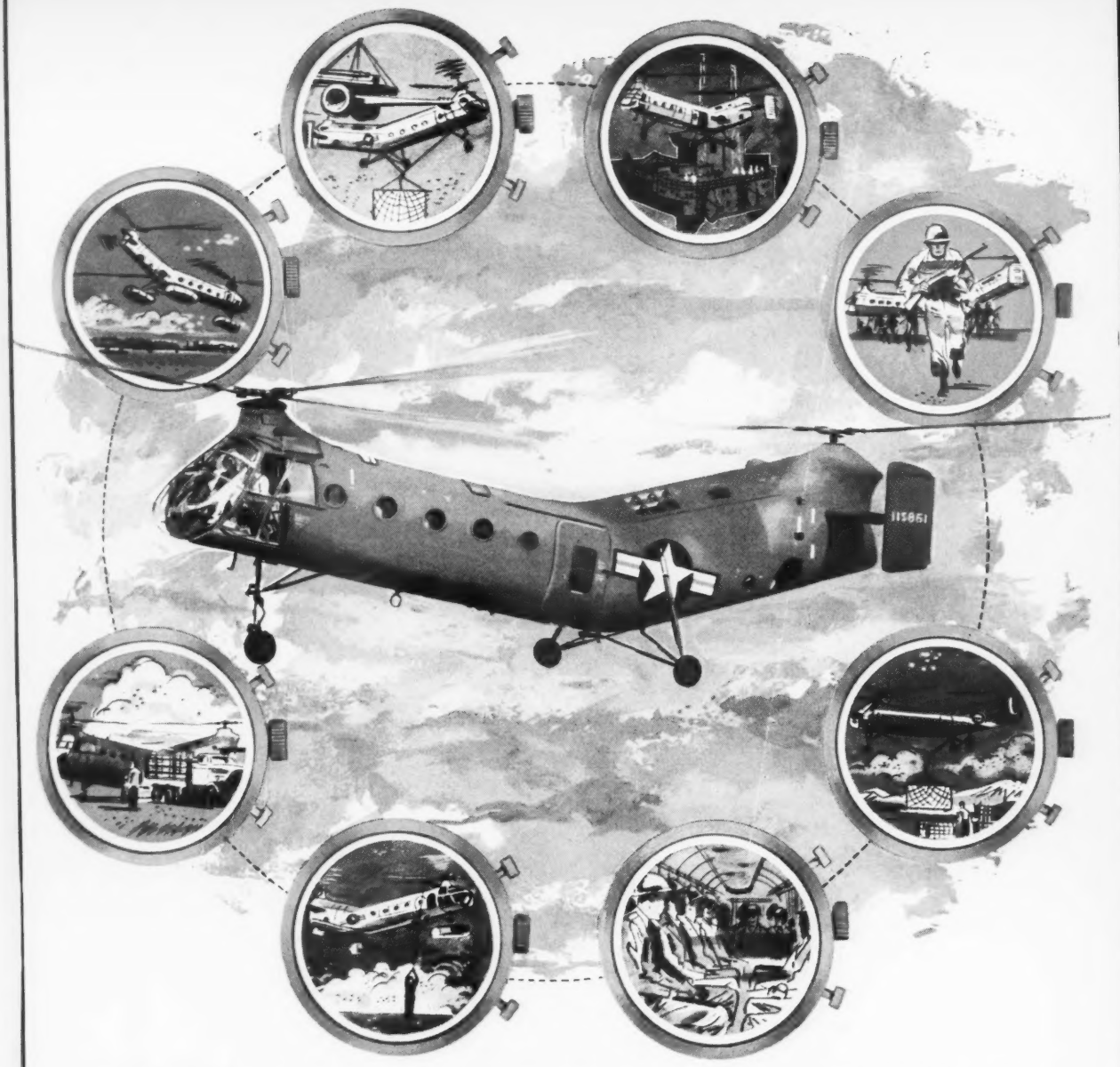


FIRST IN *development, quality, delivery and service.*

SPECIALISTS IN AIRCRAFT LANDING GEAR

menasco manufacturing company

805 SOUTH SAN FERNANDO BOULEVARD, BURBANK, CALIFORNIA



NOW A COMMERCIAL "WORKHORSE"

The familiar H-21 "Workhorse" helicopter, symbol of 'round-the-clock military mobility, will soon fly in a civilian version.

This new helicopter grows out of the massive flying experience of hundreds of H-21's – now in service in many parts of the free world. Over 50,000 hours of flight time have been accumulated by the H-21's delivered to date.

A key factor in military logistics in the U. S., Canada and France, the H-21 is being certified for civil use.

The commercial version, the Vertol 43, will seat up to 20 passengers in its long, airliner-type cabin – will be able to airlift up to 5000 lbs. of high-priority cargo.

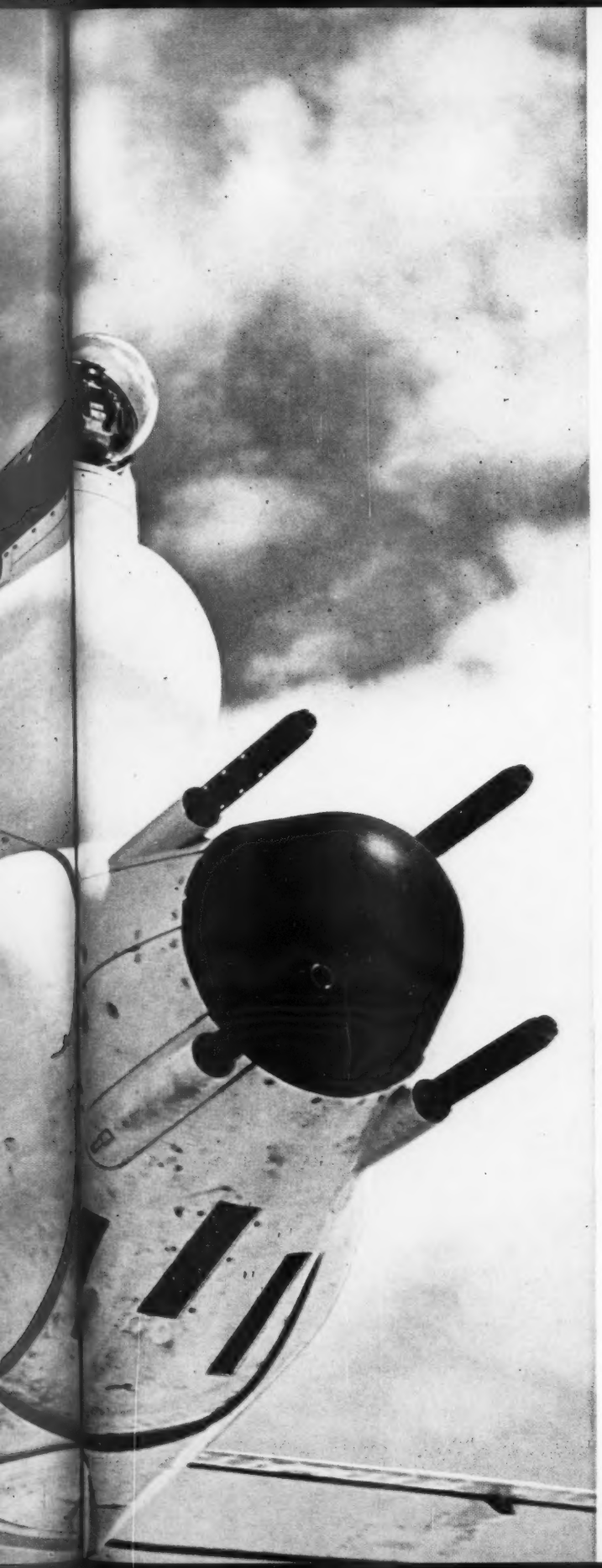
In versatility, in performance, in reliability, it will match its military counterpart – around the world, around the clock.

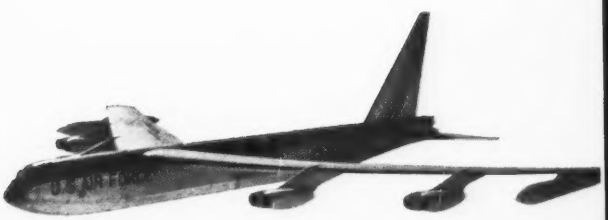
VERTOL *Aircraft Corporation*

Engineers, join Vertol's advanced engineering team!

MORTON, PENNSYLVANIA

FORMERLY PIASECKI HELICOPTER CORPORATION





The fatal sting...

defending the B-52 intercontinental bomber is the Arma MD-9 fire control system that picks up, tracks, and with uncanny accuracy fires at its target.

Developed and produced by Arma, the MD-9 is just one of Arma's capabilities in advanced weapon systems.

If you have an "ARMAment" requirement, or would like to work with a leading engineering team, contact ARMA . . . Garden City, N. Y. A division of American Bosch Arma Corporation.

ARMA

Division of American Bosch Arma Corporation

ADVANCED ELECTRONICS FOR CONTROL

A Two extension coil springs hold assembly against shaft.

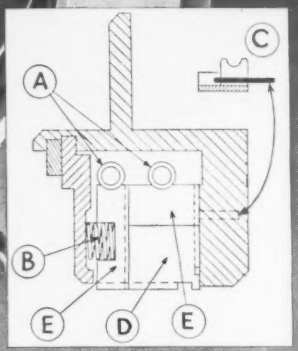
B Axial compression springs exert constant positive pressure toward the sealing face.

C Key and pin assemblies lock carbon segments against rotation.

KOPPERS CIRCUMFERENTIAL SEAL

PROVIDES UP TO 2000 hrs. OF PERFORMANCE

CAN USE LESS THAN 5 h.p.



D Flexible sealing segments permit seal to achieve same circularity as shaft.

E Straight-cut joints are covered and sealed by segmental cover ring and segmental back ring.

A number of finite joint gaps allow for ring wear.

Koppers Circumferential Seal is a segmented carbon seal ring with straight-cut joints. Its design can be modified to use step type joints or step seal joints. Primarily a gas seal, the Koppers Circumferential Seal will seal liquids if the geometry of the shaft mating faces is changed.

Koppers Circumferential Seals are one of a large variety of seals designed and manufactured by Koppers for every industrial use. Because of this complete line, Koppers can recommend, without bias, the seal best suited to your specific application. And Koppers continuous development and testing of new designs and new materials assure you of the most advanced, most efficient seals for your purpose. If you have a sealing problem, write to the KOPPERS COMPANY, INC., Metal Products Division, Piston Ring and Seal Department, 2212 Scott St., Baltimore 3, Maryland.

Engineered Products
Sold with *Service*

KOPPERS

MECHANICAL SHAFT SEALS

ENGINEERS

WE'RE LOOKING FOR MORE "TOMORROW THINKERS"

...AT REPUBLIC AVIATION

In a recent newspaper statement, Mundy I. Peale, President of Republic Aviation Corporation, stressed the increasing need in the aviation and missile industry for "men whose minds can really range the universe in complete intellectual freedom . . . what might be called 'Tomorrow Thinkers'."

The emphasis, of course, has always been on NEW IDEAS at Republic. For a quarter of a century this company has been in the forefront of aviation design, developing and building such planes as the most advanced supersonic fighter-bomber in the U. S. Air Force, the new F-105 Thunderchief—newest of the famous family of Thunder-Craft.

The pace of invention and discovery must be stepped up, in line with national necessities. Breaking the sound barrier—so tremendous an achievement only yesterday—is taken for granted today. Now the urgent need faced by Republic's designers of aircraft and missiles is to conquer the thermal barrier and the fantastic problems of hypersonic flight—and tomorrow, what new urgencies will confront us?

Practical engineering, important as it is, is not enough. We need an increasing number of engineers and scientists of inventive capacity, who are able to produce totally new theories in many fields, breaking the bonds of traditional thought. In short: "TOMORROW THINKERS."

We have many engineers and scientists with bold creative minds at Republic...and we need MORE men of this calibre. Company activities and scientific challenges are *both* expanding.

We invite professional men at all levels of experience, who feel qualified to contribute to the future of aviation, to a friendly interview...and we promise the men selected a professional working climate in which their ideas can thrive.

IMMEDIATE OPENINGS IN THESE FIELDS

Aerodynamics • Flight Test • Dynamics • Thermodynamics • Electronics • Flutter & Vibration • Servos • Weights • Weapons Systems Analysis • Analog & Digital Computers • Airframe & Mechanical Design • Antennae • Fire Control Systems • Flight Control Systems • Instrumentation • Stress Analysis • Operations Research • Preliminary Design • Systems Engineering • Propulsion • Publication Engineering

Please address complete resume of your technical background to:

AIRCRAFT
Engineering Personnel Manager MR. DAVID G. REID
Farmingdale, Long Island, N. Y.

MISSILES
Administrative Engineer MR. ROBERT R. REISSIG
223 Jericho Tpke., Mineola, Long Island, N. Y.

REPUBLIC AVIATION

The only **TEFLON® hose**

with years of flight service

...and a patented tube

TEFLON HOSE is the most reliable type of flexible line for continuous operating temperatures of −65° F to +450° F and for corrosive fluids . . . even nitric acid.

The patented compound of Teflon used in Fluoroflex®-T hose makes it unique. This compound imparts high tensile and tear strength . . . assures a leakproof seal at the coupling . . . provides thin wall tubing with proper flex life. With Fluoroflex-T hose, you're sure of high integrity, aircraft quality lines.

Resistoflex is the first and leading hose assembly manufacturer extruding its own Teflon tubing and having full control of tube quality and entire hose assembly. Over 4 years successful flight service stand back of this *original* Teflon hose. Send for details.

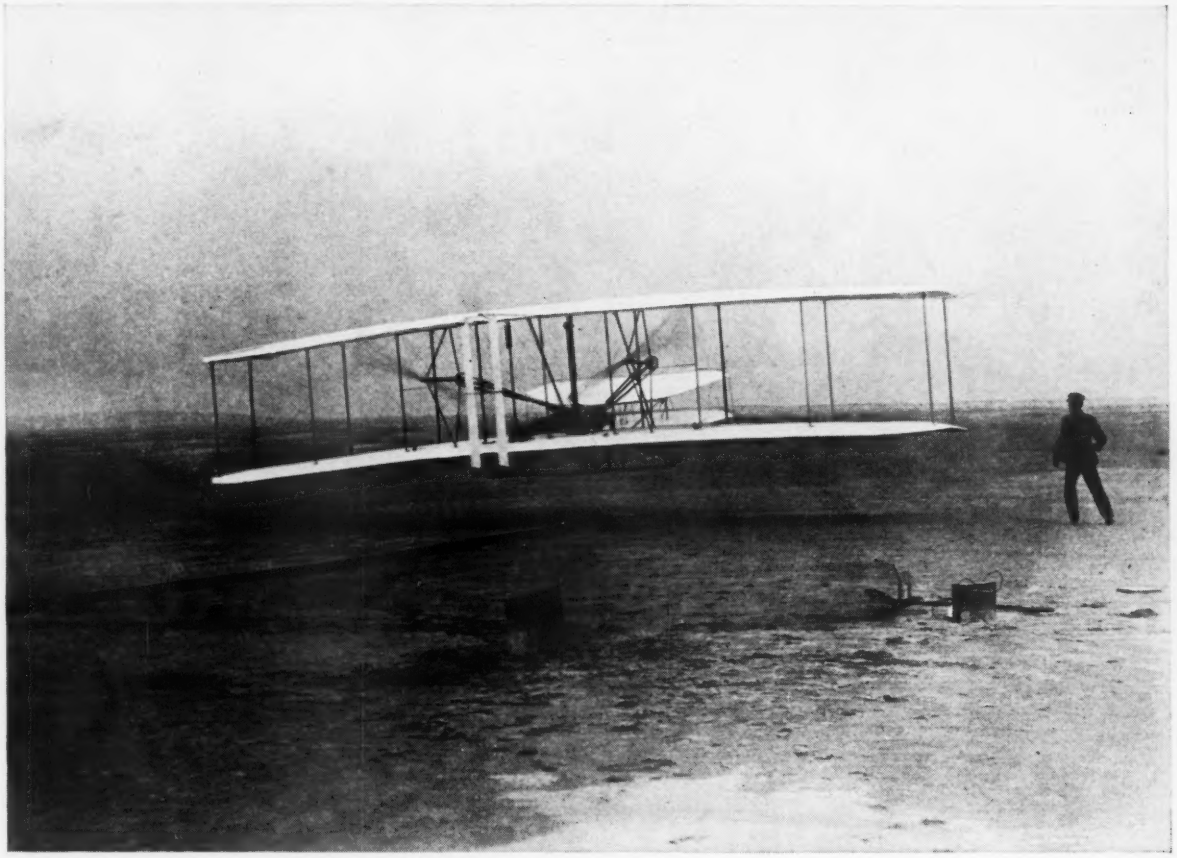
RESISTOFLEX CORPORATION, Roseland, N.J. Western Plant: Burbank, Calif.

® DuPont trade mark. • ® Resistoflex trade mark.

IF IT'S NEWS IN TEFLON HOSE – IT'S SURE TO BE FLUOROFLEX-T

20th year of service to industry

Resistoflex



Experiment by two bicycle mechanics, Kitty Hawk, 1903 BETTMANN ARCHIVE

Ever wished you had the same chance as the Wright Brothers?

You have—in missile engineering!

The Wright Brothers found existing aerodynamics concepts to be unreliable—so they formulated their own. By this ability to see further than accepted doctrine they started the mainstream of aviation development on its way. It is this power to reach beyond standard ideas that has led through every major advance in aeronautical science right up to the remarkable progress now going on in missile engineering.

If *you* have this desire to 'reach beyond' you should be with us right now. You'll find no better place to master the problems of very high speed, global-range flight.

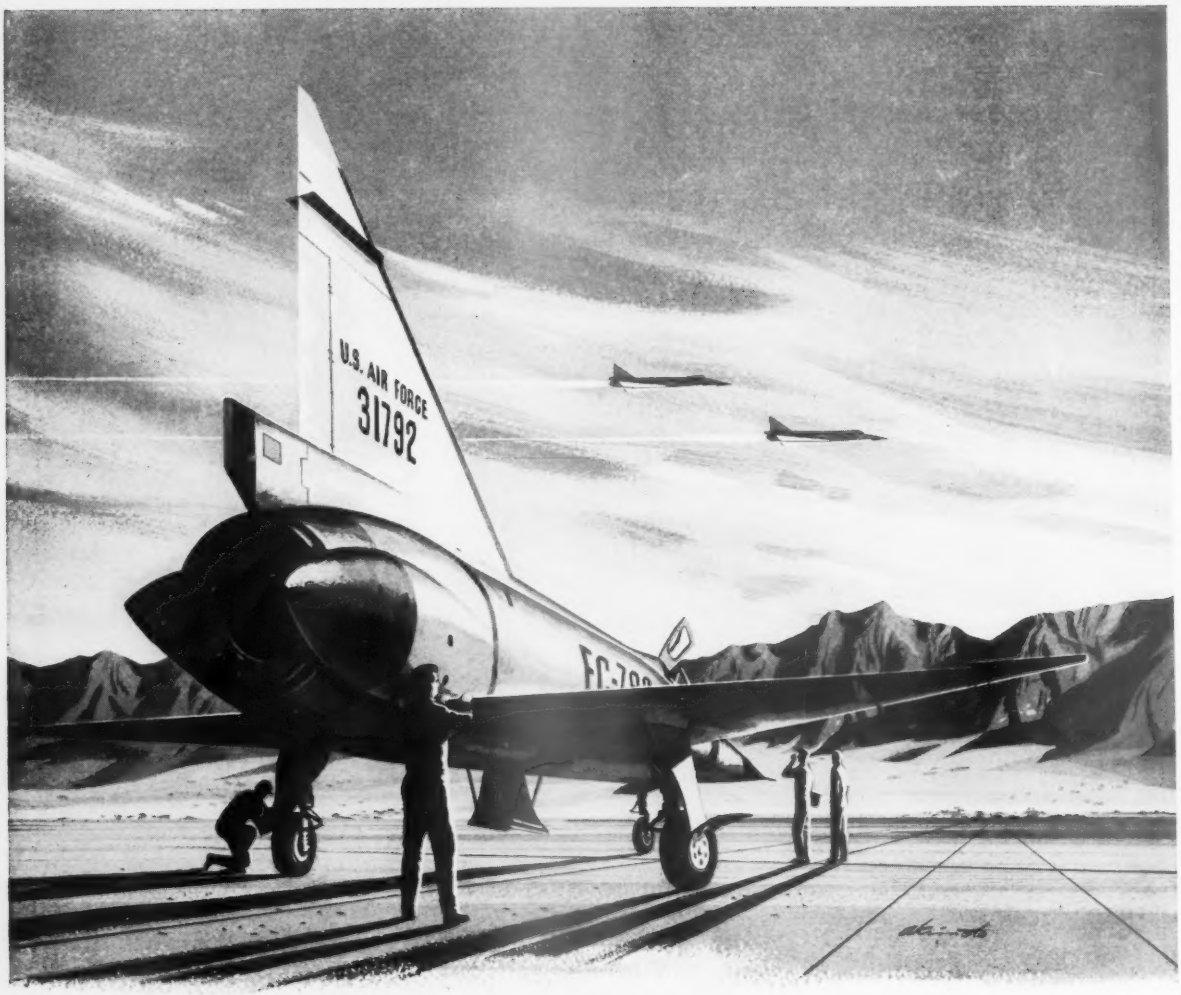
Here at North American, we are pioneers in this new era of flight. A supersonic test vehicle, the X-10, is already flying. As a leader in advanced weapons systems, we have the prime responsibility for the SM-64 Navaho Intercontinental Missile. This program is unique because it is *fully integrated;* it covers every aspect of Missile Engineering—including the most advanced developments in supersonic airframe design and manufacture, guidance and control systems, jet and rocket engines, and flight testing.

IF YOUR SPECIALTY IS LISTED HERE, WRITE TODAY FOR OUR FREE BROCHURE:

Instrumentation Design, Development & Application Standards, Drawings Checking, Specifications Writing
High Temperature Materials Engineering Structures, Stress, Flutter and Aeroelasticity Missile Airframe Design
Component and System Reliability Engineering Aerodynamics Thermodynamics Hydraulic, Pneumatic and Servo Engineering
Guidance and Flight Control Systems Evaluation Systems and Components Testing Missile and Ground Power
Engineering Flight Test Launching Equipment Field Service and Technical Training

THE ADDRESS: Mr. M. Brunetti, Engineering Personnel Dept. 91-12AER
Missile Development Division, 12214 Lakewood Blvd., Downey, California

NORTH AMERICAN AVIATION, INC.



IDEAL ENGINEERING "CLIMATE"

The many advanced aircraft and missile programs at Convair San Diego today include: *The F-102A Supersonic Interceptor, The Atlas Intercontinental Ballistic Missile, The Metropolitan 440 Airliner, the new Convair 880 Jet-Liner, and a far-reaching study of Nuclear Aircraft.*

Within these vital, highly-diversified Convair projects in beautiful San Diego, California, engineers find the perfect "climate" for a challenging and rewarding engineering career. You will find Convair salaries, computor and test facilities, engineering policies, educational opportunities and personal working advantages the most desirable in the industry.

What's more, you and your family will almost certainly enjoy a new, exciting, happier way of life here . . . where the weather year 'round is unsurpassed.

For a significant engineering career in the engineering "climate" *you* seek, we invite you to forward a full resume today. Write H. T. Brooks, Engineering Personnel, Dept. 1524.

Generous travel and moving allowances to engineers.

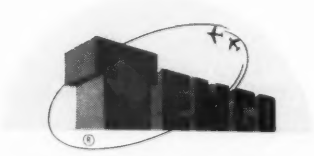
CONVAIR

C-V GD

A DIVISION OF GENERAL DYNAMICS CORPORATION

3302 PACIFIC HIGHWAY SAN DIEGO, CALIFORNIA

In Engineering, the best opportunities are in Aviation. In aviation, the best opportunities are at Temco.



AIRCRAFT CORPORATION • DALLAS

SUPERVISORY POSITIONS:

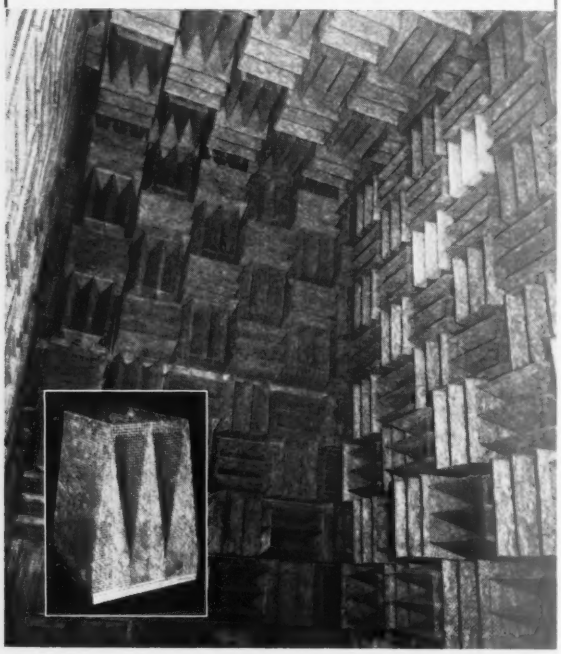
Dynamics
Power Plant Design

SENIOR ENGINEERS:

Design, Metallurgy
Weights, Structures
Structures Test, Aerodynamics

Write: Joe Russell,
Engineering Personnel, Dept. 170-A,
Temco Aircraft Corporation,
Box 6191, Dallas, Texas

AN-ECK-OIC® WEDGES



Inset shows design and construction of typical AN-ECK-OIC® WEDGE

Engineering Laboratory
Anechoic Chamber installation
Pratt & Whitney Aircraft
East Hartford, Connecticut

Another AN-ECK-OIC® WEDGE installation

Anechoic Chambers are recognized as valuable facilities for analyzing noise sources in automotive and aircraft engines, components, auxiliary machines, electric and audio equipment.

In many of the Anechoic Chambers in the United States, AN-ECK-OIC® Wedge units made by THE ECKEL CORPORATION provide the near perfect sound absorption.

Recent Anechoic Chamber installations have been constructed for General Electric Co., Pittsfield, Mass., The National Bureau of Standards, Washington, D. C.

For the silencing of Engine Test Cells, Firing Ranges, noisy machines and equipment consider the use of ECKOUSTIC® Sound Control Panels. —product of THE ECKEL CORPORATION

The Eckel Corporation Engineering and Installation organization can be helpful to you in solving your sound laboratory problems.

THE ECKEL CORPORATION

155 Fawcett Street

Cambridge 38, Massachusetts

AN-ECK-OIC® Wedges ——— ECKOUSTIC® Panels

WING THEORY

by
A. Robinson
and
J. A. Laurmann

Beginning with the pioneer work of Joukowski, Prandtl, and others, the calculation of the aerodynamic forces which act on the lifting surfaces of an airplane in flight has developed into one of the most important branches of Aeronautics.

WING THEORY includes the "classical" theory of aerofoils at low speeds as well as the latest developments in supersonic flow. The scholarship and scope of the book must assure its position as a standard work in the field of Aeronautical Engineering.

Ask to see it at your bookshop, $13.50.

CAMBRIDGE UNIVERSITY PRESS

32 East 57th Street, New York 22, N. Y.

AERODYNAMICISTS

Graduate aeronautical engineers required for work in aerodynamic techniques of high precision. This job provides an excellent opportunity to perform specialized functions including design and application of analog computers to missile and aircraft performance, stability and control, autopilot and guidance problems.

Opportunities for advancement combined with excellent company benefits and pleasant surroundings in upstate N.Y. make this an unusual opening.

For further information please call Dr. Larry Fogarty collect, Binghampton 3-6311, ext. 386.

LINK AVIATION, INC.
A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION
BINGHAMTON, NEW YORK

GPE

A RARELY PUBLICIZED OPPORTUNITY FOR MECHANICAL, AERONAUTICAL, ELECTRICAL AND ELECTRONIC ENGINEERS

Perhaps you have overlooked the tremendous opportunity that can be yours as an engineer with TWA, the world's finest airline. It may be that you have never realized that TWA has a vital, permanent need for professionally trained, graduate engineers in the fields of Mechanical, Aeronautical, Electrical and Electronic Engineering. The role of the engineer at TWA is so significant that it offers challenges and vast opportunities to engineers seeking an outlet for their talents in an organization where they can grow and prosper.

As a TWA Engineer, you begin working with a small, select group of engineering associates —have an opportunity to demonstrate your ability and to advance within the company. You will work in TWA's ultra modern, new building now nearing completion at International Airport on the outskirts of Kansas City, Mo. In Kansas City, you can enjoy all the benefits of cosmopolitan living without the hustle and bustle of the more congested industrial areas. You will enjoy many company benefits, including a company retirement plan; liberal free transportation for you and your family. Your salary will be commensurate with your experience.

Yes, here is a rare opportunity for you to advance in your engineering profession. You will undoubtedly want more information, and you can secure it by simply writing to Mr. R. Paul Day, Employment Manager, Trans World Airlines, Inc., 10 Richards Road, Kansas City, Missouri.

TRANS WORLD AIRLINES

10 RICHARDS ROAD

KANSAS CITY 5, MISSOURI

At Ramo-Wooldridge

Specification Development for ICBM and IRBM

An Unusual Opportunity for Senior Specification Engineers

Systems Engineering and Technical Direction for Atlas, Titan and Thor—Air Force Intercontinental and Intermediate Range Ballistic Missiles—are being provided by The Ramo-Wooldridge Corporation. An important aspect of this responsibility is the development of top specifications for these complex weapons systems. Also included are the coordination and integration of detailed component and sub-systems specifications.

These are specification assignments of unusual breadth. Engineers with extensive experience in the preparation of performance and acceptance specifications are invited to explore these openings.

Please address inquiries to: Mr. William Coster

The Ramo-Wooldridge Corporation

5730 ARBOR VITAE STREET • LOS ANGELES 45, CALIF.

ENGINEERS ME-EE MATHEMATICIANS

You Don't Need Previous Experience to Get Into

ADVANCED CONTROLS DEVELOPMENT

with General Electric

Whatever professional area you are now in—as long as you have an analytical mind and some scientific experience there is an excellent opportunity for you to enter CONTROLS DEVELOPMENT with the Small Aircraft Engine Department of G.E.

This field is growing in importance every day. Many current requirements are so new that the technical "know-how" must be learned on the job.

The career opportunities are obvious when you consider that every time G.E. creates a more advanced small turboprop, turboshaft or turbojet engine, an entirely new controls system must be developed to take full advantage of the powerplant's potential.

There are reputations to be won in every phase of

CONTROLS ANALYSIS

as well as

CONTROLS SYSTEM and COMPONENT DESIGN

- Relocation Expenses Paid
- Outstanding Benefit Program
- Good Starting Salary

Your reply will be handled on a strictly confidential basis.

Write to Mr. T. S. Woerz (Section R-B-1)

Small Aircraft Engine Dept.

GENERAL ELECTRIC

1000 Western Avenue West Lynn, Mass.

CHALLENGING OPPORTUNITIES IN RESEARCH AND DEVELOPMENT

for

FLUID MECHANICS ENGINEERS

Engineers of advanced standing will find challenging work at the Garfield Thomas Water Tunnel of the Ordnance Research Laboratory located at The Pennsylvania State University. This laboratory is engaged in basic and applied research in the field of underwater propulsion and related subjects, including cavitation, hydroelasticity, and hydrodynamic control of submerged bodies. The existing openings offer opportunities for combining research and development work in these fields with various academic activities.

MECHANICAL ENGINEERS

Mechanical engineers with research ability and experience in missile development.

University Faculty Appointments
Opportunities for Graduate Study
Liberal Vacation Allowances
Security Benefit Programs

Send Resume to:

ARNOLD ADDISON, Personnel Director
THE PENNSYLVANIA STATE UNIVERSITY
ORDNANCE RESEARCH LABORATORY

University Park Pennsylvania

FOR YOUR

1957 Advertising Program

AERONAUTICAL ENGINEERING REVIEW

For your monthly advertising messages to the aircraft industry's engineering and design personnel—the men who influence buying.

MEDIA BROCHURE

Now Available!

6 pages of FACTS on your market and the REVIEW.

Write for your free copy TODAY!

OFFICIAL PUBLICATION

INSTITUTE OF THE AERONAUTICAL SCIENCES, INC.

2 East 64th Street
New York, New York

IMPORTANT DEVELOPMENTS AT JPL

The Jet Propulsion Laboratory is a stable research and development center located north of Pasadena in the foothills of the San Gabriel mountains. Covering an 80 acre area and employing 1600 people, it is close to attractive residential areas.

The Laboratory is staffed by the California Institute of Technology and develops its many projects in basic research under contract with the U.S. Government.

Opportunities open to qualified engineers of U.S. citizenship. Inquiries now invited.

Integrated Teamwork in Missile Development

One of the most significant aspects of the Jet Propulsion Laboratory's progress has been its ability to develop an outstanding staff of engineers and scientists of top talent and ability. Prompt recognition of individual ability and initiative supported by authority to act has been, and is, an important factor in forming this progressive and productive research and development team.

These men, though individually responsible, work as a thoroughly integrated team on all aspects of the entire missile system instead of concentrating only on specialized missile components.

Since this includes development projects involving design, structure, propulsion, guidance, ground handling, etc., which are constantly influenced by continuing Laboratory research, the comprehensive program contains sufficient problem areas to challenge individuals of practically any phase of engineering interest.

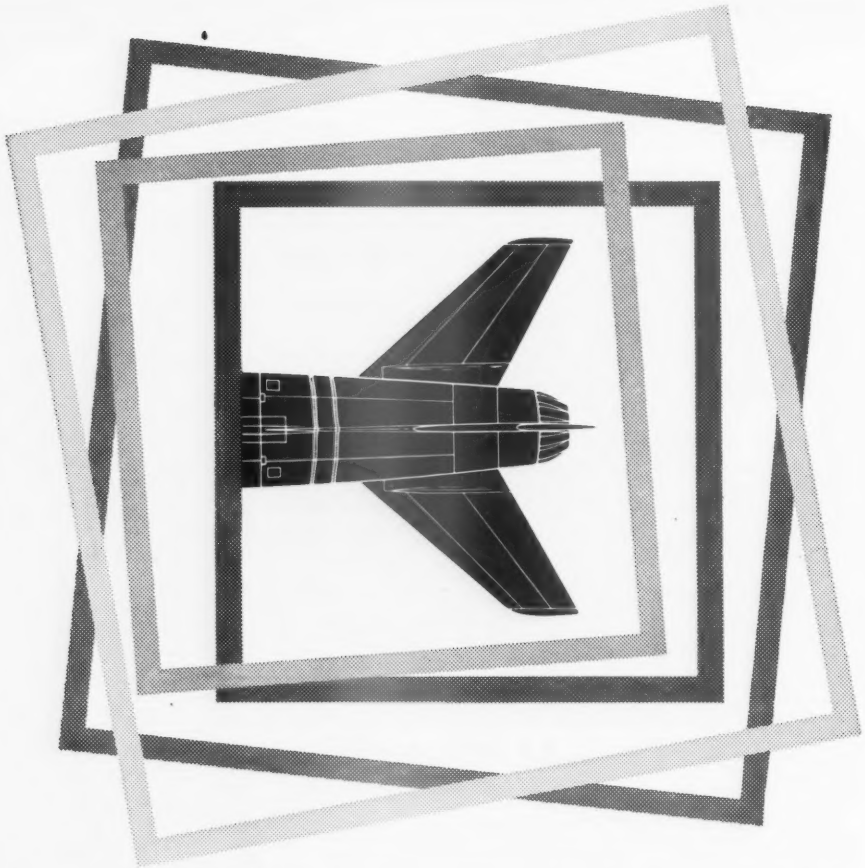
The fluid character and constant progress of such activities at the Jet Propulsion Laboratory provide a stimulating attraction to qualified people interested in pioneering in basic research, applied research and also in actual development engineering.

JOB OPPORTUNITIES IN THESE FIELDS NOW

jpl

AERONAUTICS • MECHANICAL • STRUCTURES
DYNAMICS • PROPULSION
APPLIED MECHANICS • INERTIAL ELEMENTS

JET PROPULSION LABORATORY
A DIVISION OF CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA • CALIFORNIA



NEW DEVELOPMENTS in flutter, vibration, electronics, many other specialized fields:

EXCEPTIONAL OPPORTUNITIES NOW

You can accelerate your own career considerably by working with us on some of the most advanced problems in the aviation industry—the problems of high performance aircraft, supersonic and hypersonic designs of the present and the future.

This high speed research includes design and test in Vibration, Aeroelastic and Flutter analyses, analog and digital computer techniques in Electronics, and many more.

The opportunities at North American, Los Angeles Division, are many and varied. You work surrounded by activities of a highly interesting nature, using facilities of the most advanced type. You'll enjoy wide scope for your talents, and you'll particularly like the climate of individualism and team spirit that exists. Your associates will be people who respect your opinions and professional status. Check the openings listed below.

OPENINGS ARE IMMEDIATE. PROFESSIONALLY QUALIFIED WOMEN ARE WELCOME

Recent Aeronautical Engineering Graduates • Recent Mathematics Graduates (Women) • M. E. Graduates with Vibration Experience • Recent Electrical Graduates, for Lab. work • Experienced Flutter Engineers (Aeronautical, Mechanical Engineers, Physicists, Mathematicians) • Experienced Vibrations Engineers • Experienced Instrumentation Engineers, electrical background • Experienced Analog or Digital Computer Engineers, either Electrical, Mechanical or Aeronautical Engineers, or Physicists. Heavy analog experience desirable.

ALSO NEEDED: Aerodynamicists, Systems Engineers, Instrumentation Engineers, Aero-Thermodynamicists, Aeroelastic Engineers, Cycle Analysis Engineers

Contact Les Stevenson, Engineering Personnel Office, Dept. 56-12AER
North American Aviation, Inc., Los Angeles 45, California

North American Aviation, Inc. is doing research and development on the X-15, a manned aircraft for investigation of speeds and temperatures at very high altitudes.

Los Angeles Division

NORTH AMERICAN AVIATION, INC.

NORTH AMERICAN HAS BUILT MORE AIRPLANES THAN ANY OTHER COMPANY IN THE WORLD

Index to Advertisers

A

AC Electronics Division, General Motors Corp. 180
*Aerojet-General Corp. 138, 139
Aeronautical Engineering Catalog 133, 166, 190
Aeronautical Engineering Review 170
AiResearch Manufacturing Divs., The Garrett Corp. 102, 103
Allison Div., General Motors Corp. 14
*American Steel & Wire Div., United States Steel Corp. 89
ARMA, a Div. of American Bosch Arma Corp. Inside Front Cover, 126, 127
Arwood Precision Casting Corp. 108
*Avco Defense and Industrial Products, Research & Advanced Development Div. 182

B

Bell Aircraft Corp. 172
Bendix Aviation Corp.
Bendix Computer Div. 11
*Eclipse-Pioneer Div. 67
Scintilla Div. 93
Boeing Airplane Co. 157

C

California Institute of Technology
Jet Propulsion Laboratory Div. 175
Southern California Cooperative Wind Tunnel 179
Cambridge University Press 166
Cameron Iron Works, Inc. 15
*Cannon Electric Co. 4, 5
Century Electronics & Instruments, Inc. 148
*Chain Belt Co., Shafer Bearing Div. 95
Columbus Div., North American Aviation, Inc. 145
CONVAIR, A Div. of General Dynamics Corp. 162, 171
Cornell Aeronautical Laboratory, Inc. 173

D

*Douglas Aircraft Co., Inc. 16, 141
Dow Chemical Co., The 13

E

Eckel Corp., The 166
*Eclipse-Pioneer Div., Bendix Aviation Corp. 67
*Electrical Engineering & Mfg. Corp. 77
Ex-Cell-O Corp. 71

F

Fairchild Engine and Airplane Corp., Aircraft Div. Back Cover, 137
Fenwal Inc., Aviation Products Div. 107
Fischer & Porter Co. 10
Fluid Regulators Corp. 135
Foote Bros. Gear and Machine Corp. Inside Back Cover

G

Garrett Corp., The AiResearch Mfg. Divs. 102, 103
General Dynamics Corp., CONVAIR Div. 162, 171
*General Electric Co. 73, 170, 178, 181
General Motors Corp.
AC Electronics Div. 180
Allison Div. 14
Harrison Radiator Div. 105
General Radio Co. 8
*G. M. Giannini & Co., Inc. 6
Goodyear Aircraft Corp. 1

H

Harrison Radiator Div., General Motors Corp. 105
Hydro-Aire, Inc. 147

I

International Nickel Company, Inc., The 83

J

Johns Hopkins University, The, Applied Physics Laboratory 178

K

Kaman Aircraft Corp., The 96, 97
*Kearfott Co., Inc. 76
Koppers Co., Inc.
Industrial Sound Control Dept. 87
Piston Ring & Seal Dept. 128

L

Lamb Electric Co., The 64
*Lear, Inc. 68, 69
Link Aviation, Inc. 166
Lockheed Aircraft Corp. 79
Missile Systems Div. 159

M

MB Mfg. Co. Div., Textron Inc. 84
Marquardt Aircraft Co. 7, 142
Glenn L. Martin Co., The 63, 167
Menasco Mfg. Co. 100
Minneapolis-Honeywell Regulator Co. 180

N

Norma Pencil Corp. 164
North American Aviation, Inc. 161, 176
Columbus Div. 145
Northeastern Engineering Inc. 148
Northrop Aircraft, Inc. 65, 132

P

Pack Mfg. Co. 154
Pastushin Industries, Inc. 90
Pennsylvania State University, The, Ordnance Research Laboratory 170
Pittsburgh Plate Glass Co. 133

R

Radio Corp. of America 99
Ramo-Wooldridge Corp., The 170
Republic Aviation Corp. 149, 178
Resistoflex Corp. 150
*Rohr Aircraft Corp. 9

S

Sargent Engineering Corp. 81
Scintilla Div., Bendix Aviation Corp. 93
*Shafer Bearing Div., Chain Belt Co. 95
Shell Chemical Corp. 85
A. O. Smith Corp. 75
*Solar Aircraft Co. 153
Surface Combustion Corp., Janitrol Aircraft-Automotive Div. 12
Sylvania Electric Products Inc. 91
Systems Laboratories Corp. 180

T

Temco Aircraft Corp. 165
Textron Inc., MB Manufacturing Co. Div. 84
Trans World Airlines 169

U

*United States Steel Corp., American Steel & Wire Div., Columbia-Geneva Steel Div., Tennessee Coal & Iron Div., U. S. Steel Export Co. 89

V

Vertol Aircraft Corp. 125

W

Waldes Kohinoor, Inc. 131
Wyman-Gordon Co. 192

★ *Specifications and further information on the aircraft products of these companies will be found in the* **1956 AERONAUTICAL ENGINEERING CATALOG**

The only publication of its kind devoted exclusively to the aircraft industry, this CATALOG serves as a valuable buyers' and reference guide to sources and specifications on aircraft materials, parts, and accessories. It is distributed annually to Chief Engineers, Designers, Production Heads, and Purchasing Departments of all leading Aircraft, Aircraft Engine, Instrument, Accessory, and Aircraft Parts Manufacturers; Air Transport Companies; Army, Navy, and Governmental Agencies; Research Organizations; Engineering Libraries; etc.

Published Annually by

INSTITUTE OF THE AERONAUTICAL SCIENCES

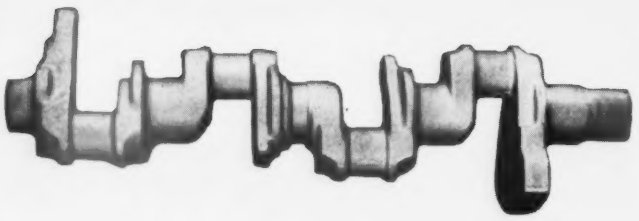
2 East 64th Street New York 21, N.Y.

whether you think in terms of

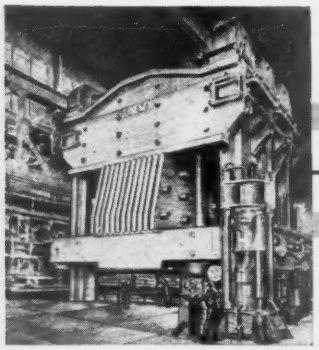
Horsepower

—or—

Thrust

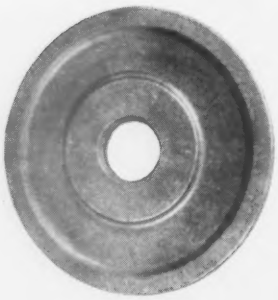


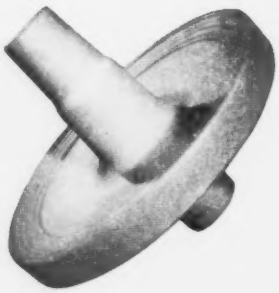
The crankshaft is the backbone of the piston-type engine. Illustrated above is the crankshaft forging for the most powerful piston-type aircraft engine ever produced.



The history of Wyman-Gordon's contribution to aircraft progress dates from the inception of the "flying machine". The jet age is now calling on the unparalleled resources of Wyman-Gordon, which include the widest range of hammer and press equipment and the greatest technical know-how in the industry. Larger and more intricate forgings than heretofore available of aluminum and magnesium are being produced on presses up to 50,000 ton capacity, and giant hammers are fulfilling the growing need for forgings of titanium, high density materials or so-called super alloys. Now, as for nearly 75 years, there is no substitute for Wyman-Gordon experience and ability for — Keeping Ahead of Progress.

At the bottom left is a turbine disc forging made from high density heat resisting alloy, and next to it is a titanium compressor wheel forging for two of the most powerful jet engines yet produced.





WYMAN-GORDON COMPANY

Established 1883

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

WORCESTER 1, MASSACHUSETTS

HARVEY, ILLINOIS • DETROIT, MICHIGAN

New Products and Product Literature of interest to IAS members

AIRCRAFT MATERIALS & PROCESSES

"Technical Data on Alcoa Hand Forgings." 16-page booklet. **Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19.**

Sintered Bearing Materials. Descriptive 4-page chart gives chemical, mechanical, and work characteristics. **Bound Brook Oil-Less Bearing Co., Bound Brook, N.J.**

"COHRfoam" Silicone Foam Rubber. This lightweight material remains soft and resilient over a temperature range of −100°F. to 480°F. **Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn.**

Bondable Teflon & Rulon. Descriptive literature. **Dixon Corp., Bristol, R.I.**

HM21XA-T8 Magnesium-Thorium Alloy. This lightweight structural airframe material withstands the intense heat generated by friction at supersonic speeds. **Dow Chemical Co., Midland, Mich.**

Silastic LS-53 Heat-Resistant Rubber. Withstands swelling caused by aircraft fuels and oils. **Dow Corning Corp., Midland, Mich.**

Formulated Epoxy Resins. Chart gives physical and electrical data on 27 resin systems. **Furane Plastics, Inc., 4516 Brazil St., Los Angeles 39.**

"Epocast 11-C" Filled Epoxy Resin. Serves as a shield against harmful radiation originating from nuclear reactors. **Furane Plastics, Inc., 4516 Brazil St., Los Angeles 39.**

Synthetic Elastomers Selector Chart. This 4-page selector No. AD24E lists the major categories of silicone compounds and typical properties of each. **General Electric Co., Silicone Products Dept., Waterford, N.Y.**

Aluminum Oxide Coatings with Flame-Plating. For parts where resistance to erosion and corrosion at high temperatures is necessary, in addition to a prolonged wear life. **Linde Air Products Co. Div., Union Carbide & Carbon Corp., 30 E. 42 St., New York 17.**

"Leadcast" Lead-Plastic Compound. Suitable as shielding for radioactive materials. **Telectro Industries Corp., 35-18 37 St., Long Island City 1.**

Special Steels for Aircraft. 22-page descriptive booklet. **U.S. Steel Corp., 71 Broadway, New York 6.**

"Fluran" Fluoro Carbon Sealants. For use as a sealing compound for aluminum and stainless steel joints in aircraft and guided missiles, in critical applications where components must be protected from highly oxidizing conditions. **U.S. Stoneware Co., Chemical Process Equipment Div., Akron 9, Ohio.**

AIRCRAFT PARTS & EQUIPMENT

Series 3200 Self-Sealing Aircraft Coupling. For use on air-frame and aircraft engine hydraulic systems with temperatures up to 275°F. and maximum pressures of 3,000 psi. **Aeroquip Corp., Jackson, Mich.**

Hydraulic & Pneumatic Components. Descriptive bulletin No. 156 covers valves, actuators, and other units. **Aircraft Products Co., Bridgeport, Pa.**

Switches. This 4-page bulletin describes propeller feathering system switches, turbojet engine starting system switches, and generator and inverter circuit switches. **Airite Products, Inc., 3516 E. Olympic Blvd., Los Angeles 23.**

Linear Strain-Gage Position Transducer. This $1/4$-in. high unit for aircraft instrumentation can be used externally on aircraft without disturbing the air stream. **Consolidated Avionics Corp., Stamford, Conn.**

Counterbored Self-Locking Anchor & Gang Channel Nuts. For structural aircraft applications. **Elastic Stop Nut Corp. of America, Union, N.J.**

Jet-Engine Harnesses & Interchangeable Thermocouples. Descriptive 4-page bulletin No. MC-141. **Fenwal Inc., Ashland, Mass.**

Thermistor Overheat Detectors. Descriptive 4-page bulletin No. MC-134. **Fenwal Inc., Ashland, Mass.**

USE THESE TEAR-OUT POSTALS TO REQUEST ADDITIONAL INFORMATION DIRECT FROM THE MANUFACTURER

Aeronautical Engineering REVIEW

REQUEST FOR PRODUCT INFORMATION

An Official Publication INSTITUTE OF THE AERONAUTICAL SCIENCES (Aviation's Professional Engineering Society)

Please send information on the following item mentioned in the ____ Issue of AERONAUTICAL ENGINEERING REVIEW

NAME ..... POSITION .....

COMPANY .....

STREET .....

CITY & STATE .....

Aeronautical Engineering REVIEW

REQUEST FOR PRODUCT INFORMATION

An Official Publication INSTITUTE OF THE AERONAUTICAL SCIENCES (Aviation's Professional Engineering Society)

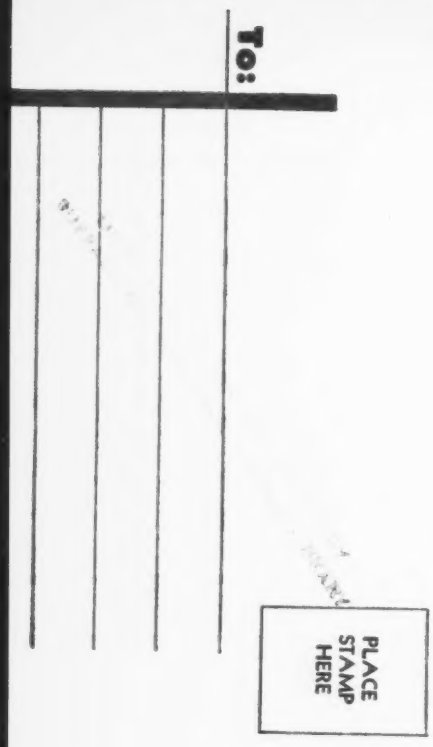
Please send information on the following item mentioned in the ____ Issue of AERONAUTICAL ENGINEERING REVIEW

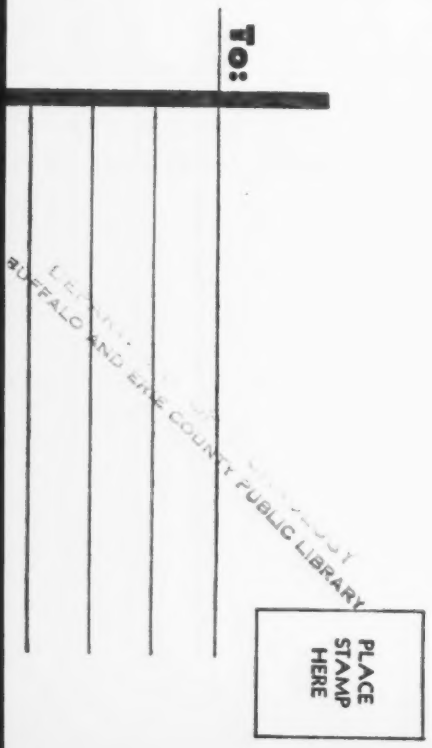
NAME ..... POSITION .....

COMPANY .....

STREET .....

CITY & STATE .....





"Flexon" Pinned Elbow Joint & "Flexon" Gimbal Joint. These two units are designed to solve problems of thermal expansion, installation misalignment, air-frame deflection, etc. **Flexonics Corp., 1309 S. Third Ave., Maywood, Ill.**

"Flexon" Bellows Design Guide. This 20-page catalog No. 155 contains information on applications, design considerations, and standards for metallic bellows. **Flexonics Corp., 1309 S. Third Ave., Maywood, Ill.**

Model 3416 Free Gyro. Features insensibility to mounting and dynamic loads. **G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena 1, Calif.**

GAB 1,000 Vacuum Pressure Switches. For use in air-borne electronic systems; respond to pressure as low as 2 in. of mercury absolute. **Gorn Electric Co., 845 Main St., Stamford, Conn.**

Null-Balance Temperature Indication System. Features 0.8-sec. full-scale response. **Handley Electronics, Inc., 14758 Keswick St., Van Nuys, Calif.**

"Tau Bolt" Blind-Application Fastener. Made from heat-treated alloy steel; features high strength in shear and tension. **Huck Mfg. Co., Detroit.**

KA-20 Lightweight Aerial Reconnaissance Camera. Weighs 20 lbs.; for use in missile and high-speed drone aircraft. **Hycon Mfg. Co., 2961 E. Colorado, Pasadena, Calif.**

F1934 Floating Anchor Nut. For use around access doors or openings that require constant grip-length screws for different thicknesses of materials; eliminates use of shims. **Kaynar Co., Kaylock Div., Box 2001, Terminal Annex, Los Angeles 54.**

Thermistor-Type Liquid Level Warning & Control Systems. Descriptive 2-page bulletin No. 563. **Liquidometer Corp., Skillman Ave. & 36 St., Long Island City 1.**

Radial Engine Suspensions. Descriptive 6-page bulletin No. 506. **Lord Mfg. Co., 1635 W. 12 St., Erie, Pa.**

Turbojet Engine Suspensions. Descriptive 6-page bulletin No. 504. **Lord Mfg. Co., 1635 W. 12 St., Erie, Pa.**

Type FG250A Tank Unit-Compensator. For use in advanced Honeywell fuel quantity measuring systems; senses amount of fuel in cell. **Minneapolis-Honeywell Aeronautical Div., 2600 Ridgway Rd., Minneapolis 13.**

Regulation of Aircraft Control Cable. Catalog describes the conditions which exist in all types of aircraft from high-speed power controlled jets to large transports, bombers, and helicopters. **Pacific Scientific Co., P.O. Box 22019, Los Angeles 22.**

"Clip-It" Steel Fastener Clip. For sliding around the bolt of a wiring or hose clamp to hold tension during arranging and while screwing on the nut. **Pastushin Industries, Inc., 5651 W. Century Blvd., Los Angeles 45.**

"Hi-Torque" Fastener. A new recess design results in full bearing thrust of the driving blade against the driving surfaces. **The Pheoll Mfg. Co., 5700 Roosevelt Rd., Chicago 50.**

Two-Way Filter-Protected Restrictor. For aircraft hydraulic systems; removes all particles larger than 0.008 in. **Purolator Products, Inc., 970 New Brunswick Ave., Rahway, N.J.**

Vibration Mounting System. For equipment protection against shock and vibration in jet or conventional aircraft. **Robinson Aviation, Inc., Teterboro, N.J.**

Series 1,000 Screwjack. Provides high tensile and compressive loads for small size to meet individual stroke and performance requirements. **Southwestern Industries, Inc., 5880 Centinela Ave., Los Angeles 45.**

Hi Psi EWB-22 Steel Aircraft Bolts. Descriptive 12-page pamphlet gives tension-tension fatigue charts and tensile and shear strength graphs. **Standard Pressed Steel Co., Box 869, Jenkintown, Pa.**

"Dubl-Lock" Couplings. For critical connections in jet aircraft high-pressure bleed air ductwork; features a clamp with a double locking safety catch. **Surface Combustion Corp., 400 Dublin Ave., Columbus 16, Ohio.**

Three-Axis Automatic Pilot. Operates pneumatically and weighs less than 10 lbs. **Tactair, Inc. Div., Aircraft Products Co., Bridgeport, Pa.**

Pressure Control Block. This packaged hydraulic unit is designed for use in aircraft auxiliary drive systems. **Vickers Inc., Detroit.**

Model 640 Aircraft Clock. This 8-day elapsed time clock records time of trip with independent stopping device. **Wakmann Watch Co., Inc., 15 W. 47 St., New York 36.**

ELECTRONIC & ELECTRICAL EQUIPMENT

Radio & Electronic Parts & Equipment. Descriptive 356-page 1957 catalog No. 160; lists over 27,000 items. **Allied Radio Corp., 100 N. Western Ave., Chicago 80.**

DP-12 Sealed Potentiometer. Withstands the extremes of atmospheric conditions. **Dale Products, Inc., Box 136, Columbus, Neb.**

Precision Rotary Switches. Descriptive 26-page catalog. **The Daven Co., Newark, N.J.**

Printed Circuit Connectors. Descriptive 12-page technical brochure. **DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1.**

Size 11 Induction Potentiometer. The placement of the input windings on the stator relieves the brushes and collector rings from the necessity of carrying current. **Diehl Mfg. Co., Finderne Plant, Somerville, N.J.**

Regulated D.C. Power Supply. For high-current applications requiring fast recovery time. **Dressen-Barnes Corp., 250 N. Vinedo Ave., Pasadena, Calif.**

BUFFALO AND ERIE COUNTY PUBLIC LIBRARY

Temperature Compensated D.C. Tachometer Generators. For speed indicating wherever visual or automatic control is called for. **Electric Indicator Co., Springdale, Conn.**

Instruments & Components. 8-page catalog describes impedance and comparison bridges, decade resistance and capacitance standards, and high linearity decade voltage dividers. **Electro-Measurements, Inc., 7524 S.W. Macadam Ave., Portland 1, Ore.**

PRM123 Sealed Rotary Potentiometer. Covers 100 to 50,000 ohms. **General Controls Co., Glendale, Calif.**

Model DDL Potentiometer-Type Accelerometer. For transonic and supersonic guided missiles and aircraft flight-control applications. **Genisco, Inc., 2233 Federal Ave., Los Angeles 64.**

Miniature Wire-Wound Trimmer Potentiometer. Features resistances from 100 to 40,000 ohms, resolutions ranging from 0.3 to better than 0.1 per cent, and power rating of one watt at 40°C. **Handley Electronics, Inc., 14758 Keswick St., Van Nuys, Calif.**

Unbalance Detector Negative Sequence Sensing Relay. Protects 115-200-volt, 3-phase, 400-cycle power systems. **Hartman Electrical Mfg. Co., Mansfield, Ohio.**

Series 5,300 Potentiometer. Measures 1 1/4 in. in dia. and weighs 2 oz. **Helipot Corp., 916 Meridian Ave., S. Pasadena, Calif.**

Ceramic-Body Heating Cartridges. For instruments requiring stabilized ambient temperature ranges; smallest unit measures 5/32 in. in dia. by 1 in. in length. **Hotwatt, Inc., 16 Gould St., Danvers, Mass.**

"Hycon-Verter" Transistor Magnetic Power Supply. This 2 by 2 1/2 by 3 in. unit is designed to replace small vibrators, inverters, or dynamotors. **Hycon Mfg. Co., 2961 E. Colorado St., Pasadena, Calif.**

1,000-Volt Silicon Diodes. For power applications where high ambient temperature and miniaturization are prime factors. Bulletin No. SR-138. **International Rectifier Corp., El Segundo, Calif.**

All-Magnetic 400-Cycle A.C. Line Voltage Regulator. Delivers a sinusoidal output despite a.c. input distortions. **Magnetic Research Corp., 200 Center St., El Segundo, Calif.**

Subminiature Servoamplifiers. For use with 400-cps servomotors in airborne service. **The W. L. Maxson Corp., Maxson Instruments Div., 47-37 Austell Place, Long Island City 1.**

Miniature Aviation Circuit Breaker. Weighs 1.5 oz. and operates satisfactorily under conditions of extreme heat and severe cold. **Mechanical Products, Inc., Jackson, Mich.**

F-70334-1 Relay. Hermetically and individually sealed contacts eliminate the possibility of contact contamination. **Revere Corp. of America, Wallingford, Conn.**

"Permacode" Teflon Hook-Up Wires. Descriptive 2-page bulletin No. 1901. **Revere Corp. of America, Wallingford, Conn.**

Model MA6501 Tubeless D.C. Source. Provides 6VDC and 2VDC output voltages regulated to within ±0.01 per cent. **Sorensen & Co., Inc., Fairfield Ave., Stamford, Conn.**

2-Lb. 50-Watt Power Supply. These lightweight, miniature units are suitable for guided missiles, rockets, and aircraft applications. **Universal Atomics Corp., 19 E. 48 St., New York 17.**

Model 1,081 Miniature Hermetically Sealed Relay. For applications where compactness and light weight are essential. **Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N.J.**

PRODUCTION & MAINTENANCE EQUIPMENT

MA-3 Ground Support Weather Simulator. For ground check-off and maintenance of air-borne electronic equipment. **American Electronics, Inc., El Monte, Calif.**

Inspection Periscope. Designed to furnish a close look at the internal walls of aircraft fuel tanks. **Testa Mfg. Co., 10130 E. Rush St., El Monte, Calif.**

"Vertiflow" Vertical Flow Unit Heaters. Heats airplane hangers having extremely high ceilings difficult to heat because of air stratification. **Young Radiator Co., Racine, Wis.**

RESEARCH & TEST EQUIPMENT

Type C Calibrator. Calibrates any type of wire strain transducer, as well as thermocouples and potentiometers. **Allegany Instrument Co., Inc., 1091 Wills Mountain, Cumberland, Md.**

K-7 Error Computer. Isolates the magnitude, polarity, and location of errors in the whole wire strain transducer system. **Allegany Instrument Co., Inc., 1091 Wills Mountain, Cumberland, Md.**

Research, Engineering, & Development. Company brochure describes their facilities and services. **Allied Research Associates, Inc., 43 Leon St., Boston.**

USE THESE TEAR-OUT POSTALS TO REQUEST ADDITIONAL INFORMATION DIRECT FROM THE MANUFACTURER

Aeronautical Engineering REVIEW

REQUEST FOR PRODUCT INFORMATION

An Official Publication INSTITUTE OF THE AERONAUTICAL SCIENCES (Aviation's Professional Engineering Society)

Please send information on the following item mentioned in the _____ Issue of AERONAUTICAL ENGINEERING REVIEW

NAME..... POSITION.....

COMPANY.....

STREET.....

CITY & STATE.....

Aeronautical Engineering REVIEW

REQUEST FOR PRODUCT INFORMATION

An Official Publication INSTITUTE OF THE AERONAUTICAL SCIENCES (Aviation's Professional Engineering Society)

Please send information on the following item mentioned in the _____ Issue of AERONAUTICAL ENGINEERING REVIEW

NAME..... POSITION.....

COMPANY.....

STREET.....

CITY & STATE.....

To:

PLACE STAMP HERE

To:

PLACE STAMP HERE

DEPARTMENT OF TECHNOLOGY
PUBLIC LIBRARY

Strand Burner. Measures burning rates of explosives and fuels to closest 0.01 of a sec.; bulletin No. 4066. **American Instrument Co., Inc., Silver Spring, Md.**

Model 1079C Vibrating Reed Electrometer. For the critical measurement of small d.c. currents and voltages at high impedance encountered in radioactivity and p^H studies. **American Tradair Corp., 34-01 30 St., Long Island City 6.**

RF Gas Analyzer. Descriptive 4-page bulletin No. 488. **Beckman Instruments, Inc., Scientific Instruments Div., Fullerton, Calif.**

Series 500 Air Controller. For measuring and controlling such variables as pressure, vacuum, temperature, liquid level, flow, differential pressure, and mechanical motion. Bulletin No. A130. **The Bristol Co., Waterbury 20, Conn.**

High-Speed Self-Balancing Recording Potentiometers. For use with analog-to-digital conversion devices. **The Bristol Co., Waterbury 20, Conn.**

"4 Dimensions in Digital Design." This 16-page booklet discusses the art of using digital techniques for testing, information handling, and control. **Burroughs Corp., Electronic Instruments Div., 1209 Vine St., Philadelphia 7.**

Central Compression System. This 12,000-psi central compression system speeds development of pneumatic components, high-pressure processes. **Cardox Corp., 307 N. Michigan Ave., Chicago 1.**

Model 103A Stroboscope Synchronizer. This instruments permits watching of shake tests in slow motion or stopped in any selected cyclic position. **Chadwick-Helmuth Co., 472 E. Duarte Rd., Monrovia, Calif.**

Model SU-120-4 Low-Temperature Chilling Machine. For laboratory testing in regard to quality control and product development uses. **Cincinnati Sub-Zero Products, 3930 Reading Rd., Cincinnati 29.**

Decimal Digitizers. Descriptive 4-page bulletin No. CR-181. **Coleman Engrg. Co., Inc., 6040 W. Jefferson Blvd., Los Angeles 16.**

Instruments for Analysis, Control, & Data Processing. Descriptive 30-page catalog No. 1305. **Consolidated Electrodynamics Corp., 300 N. Sierra, Madre Villa, Pasadena, Calif.**

Type 1213-C Calibrator. For the calibration of oscillators, receivers, and other wide-range devices up to frequencies above 1,000 mc. **General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.**

Model SP-101 Pressure Scanner. Enables the measurement of up to twelve pressure sources with one transducer. **G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena 1, Calif.**

Vibration Pickups & Meters. Descriptive 6-page bulletin No. 124E for use by design and test engineers engaged in vibration analysis. **MB Mfg. Co., 1060 State St., New Haven 11, Conn.**

Model 60 Logarithmic Converter. For use with the Moseley autograf X-Y recorder in applications where d.c. output voltages proportional to the logarithm of the input voltages are required. **F. L. Moseley Co., 409 N. Fair Oaks Ave., Pasadena 3, Calif.**

No. 7-18 Frequency Meter. Measures frequency in the 100- to 10,000-mc range. **Northeastern Engrg., Inc., Manchester, N.H.**

Mobile Air Monitor. Automatically measures and records air-borne radioactivity and warns by light and bell when preset limits are exceeded. **Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18.**

"Dampometer" Logarithmic Decrement Frequency. For automatic recording of the logarithmic decrement and frequency of oscillation. **Oltronix Co., 235 Underwood Dr., Atlanta 5, Ga.**

Digital Indicating Instrument. For applications in both testing and processing for the measurement of temperature, pressure, load, speed, flow, or any other variable which can be translated into an electrical quantity. **Performance Measurements Co., 15301 W. McNichols Rd., Detroit 35.**

Lightweight Radar Beacon. This $2^1/_2$-lb unit enables ground crews to track a guided missile in flight. **Radio Receptor Co., Inc., Brooklyn, N.Y.**

400 Series Analog Computer. Descriptive 16-page brochure No. 108. **Reeves Instrument Corp., 207 E. 91 St., New York 28.**

"Pyro-Couple" Surface Thermometer. Descriptive leaflet No. 2P756. **Royco Instruments, 830 Arthur St., Albany, Calif.**

Electromechanical Assembly Components Service Units. 12-page brochure No. TDS1110 describes "Servoboard" assembly kits. **Servo Corp. of America, 20-20 Jericho Tpk., New Hyde Park, N.Y.**

Research, Design, & Test Equipment. 16-page short form catalog No. SF9901 describes various systems, equipment, and components. **Servo Corp. of America, 20-20 Jericho Tpk., New Hyde Park, N.Y.**

Internal Calibrating Master. Checks internal dimensions from 5 to 36 in. **The Sheffield Corp., Dayton 1, Ohio.**

NEW LITERATURE OFFERED BY ADVERTISERS

"Hyco-Span Aircraft Cable." Booklet. **American Steel & Wire Div., Rockefeller Bldg., Cleveland 13.** *See page 89*

General Purpose Digital Computers. **Bendix Computer Div., 5630 Arbor Vitae St., Los Angeles 45.** *See page 11*

YOUR BEST MOVE

See Foote Bros. first for all of your gear and geared assembly needs!

There's a good reason why many of the nation's leading producers of aircraft engines and air frames see Foote Bros. first for precision gearing, power transmissions and all types of mechanical actuators. It's because Foote Bros. offers unmatched experience in design and production engineering plus complete facilities for precision prototype and volume production . . . as well as complete testing facilities for proving out performance before delivery.

This is your best reason for making your next move . . . contact Foote Bros. for all of your precision gearing needs. Every Foote Bros. geared assembly represents the very finest in engineering, manufacturing technique, quality control and reliability. Your best move . . . call Foote Bros. today!

This main rotor transmission for a leading transport helicopter typifies the precision assemblies supplied to the aircraft industry by Foote Bros.

FOOTE BROS.

Better Power Transmission Through Better Gears

Since 1859

Foote Bros. Gear and Machine Corporation
4545 South Western Boulevard, Dept. G
Chicago, Illinois

This trademark stands for the finest industrial gearing made!

FOOTE BROS. Duff-Rolled LIFETIME GEARING

The C-123 can't stop on a dime—

but it can land in 700 feet!

FAIRCHILD

AIRCRAFT DIVISION • HAGERSTOWN 10, MARYLAND

A Division of Fairchild Engine and Airplane Corporation

...WHERE THE FUTURE IS MEASURED IN LIGHT-YEARS!

Meet the most agile, the most sure-footed transport in the world – the Fairchild C-123. It is capable of air-lifting up to 60 troops, or up to eight tons of bulk combat cargo—and it needs no mile-long concrete runway.

Almost any clearing, almost any field is a potential C-123 airbase; even deeply rutted, ungraded, or sandy grounds are taken in stride by this rugged ship. And sophisticated aerodynamic design makes possible a landing run of only 700 feet—a takeoff run only a little longer.

Performance, ruggedness, payload and versatility . . . these are traditional hallmarks of Fairchild aircraft.

DEC 19

feet!

dy grounds ar
gged ship. An
c design mak
only 700 feet
longer.
s, payload an
traditional hal
ft.

DEC 18